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RIVETING

ALCOA ALUMINUM



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Aluminum alloy bridge. The girders are assembled with $\frac{7}{8}$ " diameter A17S-T3 rivets—squeeze driven.

RIVETING ALCOA ALUMINUM AND ITS ALLOYS

RIVETING is the most commonly used method for joining aluminum, particularly the structural alloys which depend upon heat treatment for their high mechanical properties. In the smaller sizes aluminum alloy rivets are always used. For the thicker sections used in larger structures, either aluminum alloy or steel rivets may be used, the choice depending upon conditions attending the erection of the structure.

Steel rivets are stronger than aluminum alloy rivets and, when driven hot, offer certain advantages in ease of driving from the standpoint of equipment required. However, their use is limited to those applications in which the structure can be protected adequately against corrosion. Aluminum alloy rivets make possible the maximum saving in weight and offer the greatest resistance to corrosion.

Aluminum alloy rivets may be made from practically any of the wrought aluminum alloys, but the following Alcoa alloys, commercially available in rivets, adequately fill the requirements as regards range of properties and driving characteristics: 2S (commercially pure aluminum), A17S, 17S, 24S, 53S, 61S, and B77S.

With the exception of 17S, 24S, and B77S rivets, all are driven cold in the condition in which they are received from the manufacturer. The latter six alloys are always used in a heat-treated temper, since only in such a temper do they have the desired mechanical properties. However, as will be explained later, 17S, 24S and 61S rivets are reheat treated immediately before driving in order that they can be driven more easily. To indicate that the rivets have been heat

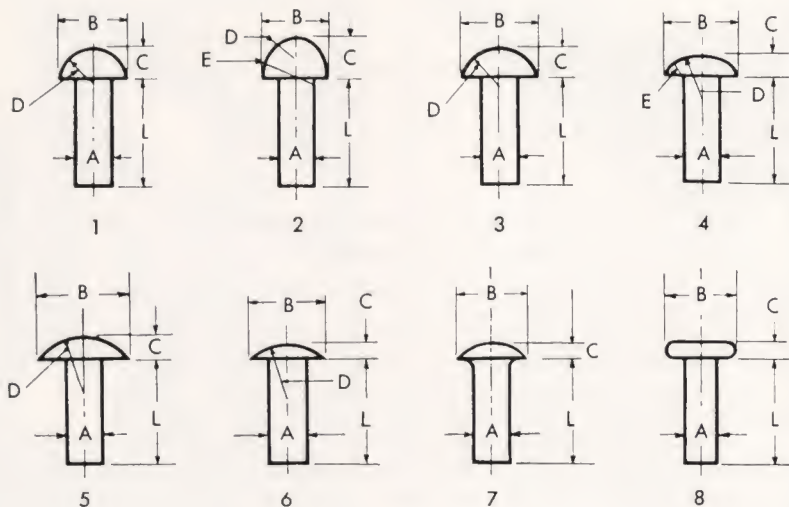


FIGURE 1 — Common Types of Heads Supplied on Aluminum Alloy Rivets

Kind	Military Specifications		Head Diameter B	Head Depth C	Head Radius D	Edge Radius E
	MIL-R-1150A	MIL-R-5674A				
1. Standard Button Head	Type 6 or B-1	.....	1.75A	0.75A	0.885A	.....
① 2. High Button Head — ("Acorn" Type) American Standards	Type B-2	.....	1.50A+ 0.031	0.75+ 0.125	0.75— 0.281	0.75+ 0.281
3. Round Head	Type 3	AN430 ⑥	2A	0.75A	1.042A	.....
4. Mushroom Head	Type 5	.....	2A	0.625A	1.634A	0.50A
5. Standard Brazier Head	Type 2	AN455 ⑥	2.50A	0.50A	1.8125A	.....
② 6. Modified Brazier Head	.....	AN456	.....	.....	.....	.....
7. Universal Head	.....	AN470	2A	0.43A	.....	0.875A
8. Flat Head	Type 4	AN442 ⑥	2A	0.40A	.....	.....

①The high button head supplied in sizes 1/2-inch and larger.

②For head dimensions see drawing AN456

③For sizes 1/2-inch and larger.

④Oval depth (F)=0.25A.

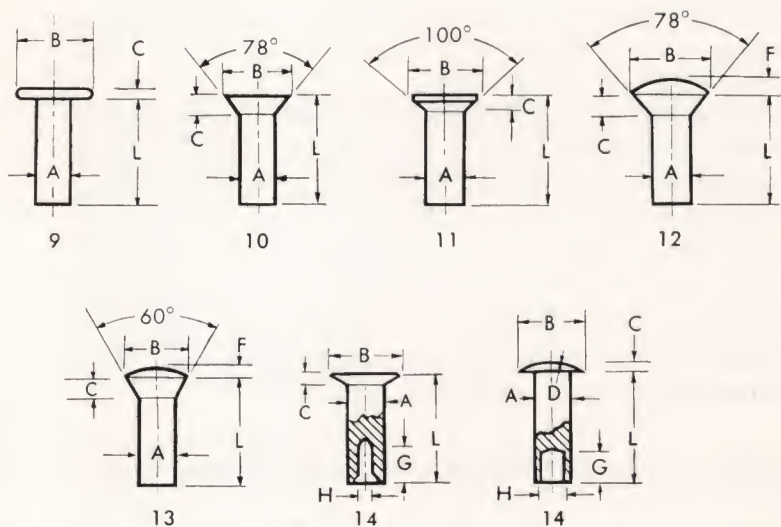


FIGURE 1 (Concluded) — Common Types of Heads Supplied on Aluminum Alloy Rivets

Kind	Military Specifications		Head Diameter B	Head Depth C	Head Radius D	Edge Radius E
	MIL-R-1150A	MIL-R-5674A				
9. Tinnert's Rivets	.....	.....	2.25A	0.30A	.....	.....
10. 78° Flat Ctsk. Head	Type 7	.....	1.81A	0.50A	.....	.....
11. 100° Flat Ctsk. Head	Type 9	AN426	See Table 14			
④ 12. 78° Oval Ctsk. Head	Type 8	.....	1.81A	0.50A	1.7656A	.....
⑤ ③ 13. 60° Oval Ctsk. Head	Type C-2	.....	1.577A	0.50A	.....	.....
14. Tubular shank	.....	AN450	Drawing covers both head styles.			
14. Tubular shank	.....	.....	Head styles to Tubular Rivet Standards.			

⑤ Oval depth (F) = 0.187A.

⑥ Inactive for design 3-30-48 — Use AN-470.

treated, letters and numbers are added to the alloy designations, as for example: A17S-T4, 17S-T4, 24S-T4, 53S-T61, 53S-T4, 61S-T6, and B77S-T4.

Aluminum alloy rivets are furnished with various types of heads, as shown in Figure 1, pages 6 and 7. Button, round, mushroom, brazier, and flat head rivets are furnished with a small fillet at the junction of the shank and head. The radius of this fillet is equal to about one-tenth of the shank diameter, with a minimum of 0.01 of an inch. In some cases these suffix numbers are changed after the rivets have been driven to indicate that the temper has been changed by driving. These temper designations are shown in Table 1.

TABLE 1 — Alcoa Temper Designations for Heat-Treated Rivets ①

Alloy	Old Temper Designation	New Temper Designation	
		Heat-Treated by Alcoa	Driven Rivets
17S	{ —T —T	—T4 —T4	—T3 ^② —T31 ^③
A17S	—T	—T4	—T3 ^②
24S	—T	—T4	—T31 ^③
53S	{ Any Temper —T —T61	 —T6 —T61	—T41 ^④ —T6 —T61
61S	{ —W —T Any Temper	—T4 —T6	—T31 ^③ —T6 —T43 ^④
B77S	.....	—T4	—T41

① Also available in —O and —F tempers.

② Driven cold after full natural aging.

③ Driven cold immediately after solution heat treatment, or when refrigerated to defer natural aging.

④ Driven hot, at the solution heat treating temperature.

STRENGTH OF RIVETED JOINTS

IN order to determine the strength of a riveted joint, it is necessary to know the strength of the individual rivets. Failure of a rivet may occur in either of two ways, by shearing on one or more planes, or by crushing the metal at the point where the rivet bears against the plates or shapes. The load per rivet at which each of these two types of failure may occur is separately calculated and the lower of the two governs the design. The data required to calculate these ultimate loads are given in the following paragraphs.

SHEAR FAILURES

The load at which a driven rivet will shear may be calculated as follows:

$$\text{Ultimate load per rivet} = f_s \times A_s \times N$$

where f_s = ultimate shear strength of the metal in the shank of the driven rivet, lb./sq. in.,

A_s = cross-sectional area of the shank of the driven rivet, sq. in.,

N = number of planes along which the rivet tends to shear; viz., single shear, double shear.

Values of f_s are given in Table 2, page 10. These are average values based on actual tests of driven rivets in which the ultimate load per rivet was divided by the area of the hole to determine the shear strength. In the case of most of the cold-driven rivets, the values are slightly greater than the corresponding shear strengths of the undriven material. The increase is attributed partly to the work hardening of the metal as it upsets to fill the hole, and partly to the swelling of the hole itself which increases the cross-sectional area of the finished rivet.

The most logical value to use for A_s in the foregoing formula is the area of the hole, because examination of many

driven rivets by sectioning has shown that the rivets invariably fill the hole if properly driven. Tables 3 and 4 show recommended hole diameters for aluminum alloy rivets and the corresponding single shear areas, A_s .

The number of planes on which a rivet tends to shear, N , in the foregoing formula for ultimate load per rivet, depends entirely on the type of joint. In most cases, rivets are used either in single or double shear, but occasionally they are used in triple or even quadruple shear. For design purposes, the load required to shear a rivet may be assumed to increase

TABLE 2 — Average Ultimate Shear Strengths of Driven Rivets

These values are for rivets driven with cone-point heads. Rivets driven with heads requiring more pressure may be expected to develop slightly higher strengths.

Alloy and Temper ① Before Driving	Driving Procedure	Alloy and Temper After Driving	Average Shear Strength Lbs. per Square Inch
2S-F	Cold, as-received	2S-F	11,000
A17S-T4	Cold, as-received	A17S-T3	33,000
17S-T4	Cold, as-received	17S-T3	39,000
17S-T4	Cold, immediately after quenching	17S-T31	34,000 ^②
24S-T4	Cold, immediately after quenching	24S-T31	42,000 ^②
53S-T61	Cold, as-received	53S-T61	23,000
53S-T6	Cold, as-received	53S-T6	26,000
61S-T6	Cold, as-received	61S-T6	30,000
61S-T4	Cold, immediately after quenching	61S-T31	24,000 ^②
Steel	Cold, annealed	Steel	40,000
53S-T4	Hot, 960° to 1050° F	53S-T41	18,000 ^{②③}
61S-T4	Hot, 990° to 1050° F	61S-T43	24,000 ^②
B77S-T4	Hot, 850° to 975° F	B77S-T41	38,000 ^②
Steel	Hot, 1700° to 1900° F	Steel	45,000

① These designations should be used when ordering rivets.

② Immediately after driving, the shear strengths of these rivets are about 75% of the values shown. On standing at ordinary temperatures they age harden to develop their full strength, this action being completed in about four days for 17S-T31 and 24S-T31 rivets. The values shown for 61S-T31, 53S-T41, and 61S-T43 rivets are attained in about two weeks. Values of 26,000 psi are attained by 61S-T31 rivets about four months after driving. The value shown for B77S-T41 rivets is attained in about one week.

③ This shear strength is for rivets driven at temperatures of 960° to 980° F. The shear strength increases about 1000 lb. per square inch for each increase of 12° F. in driving temperature. Thus, if the driving temperature range is carefully maintained at 1030° F. to 1050° F., an average shear strength of 24,000 lb. per square inch will be developed in the driven rivets.

TABLE 4 — Recommended Hole Sizes for Hot Driven Aluminum Alloy Rivets
with Corresponding Shear and Bearing Areas

Nominal Rivet Diameter, Inch	$\frac{3}{16}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1
Recommended Hole Diameter, Inch	0.397	0.469	0.531	0.656	0.781	0.922	1.063
Corresponding Drill Size	X	$1\frac{1}{2}$	$1\frac{7}{8}$	$2\frac{1}{2}$	$2\frac{5}{8}$	$2\frac{3}{4}$	$3\frac{1}{8}$
Corresponding Single Shear Area, Sq. In.	0.1238	0.1728	0.2215	0.3380	0.4791	0.6677	0.8875
Sheet and Plate Thicknesses	0.081	.....	.....	.....	.....	.....	.....
	0.102	0.0478	.....	.....	.....	.....	.....
	$\frac{1}{8}$	0.0586	0.0664	0.0820	0.0976	0.1153	0.1329
	$\frac{5}{32}$	0.0620	0.0830	0.1025	0.1220	0.1441	0.1661
	$\frac{3}{16}$	0.0744	0.0879	0.1230	0.1464	0.1729	0.1993
	$\frac{7}{32}$	0.0868	0.1026	0.1435	0.1708	0.2017	0.2325
	$\frac{1}{4}$	0.0993	0.1173	0.1640	0.1953	0.2305	0.2658
	$\frac{5}{16}$	0.1241	0.1466	0.2050	0.2441	0.2881	0.3322
	$\frac{3}{8}$	0.1489	0.1759	0.2460	0.2929	0.3458	0.3986
	$\frac{7}{16}$	.....	0.2052	0.2870	0.3417	0.4034	0.4651
	$\frac{1}{2}$	.....	0.2655	0.3280	0.3905	0.4610	0.5315
	$\frac{5}{8}$	.....	.....	0.3690	0.4393	0.5186	0.5979
	$\frac{3}{4}$	.....	Bearing Area Sq. In.		0.4881	0.5768	0.6644
	$\frac{11}{16}$	.....			0.5369	0.6339	0.7308
	$\frac{13}{16}$	.....			0.5858	0.6915	0.7973
	$\frac{7}{8}$	.....			.....	0.7491	0.8637
	1	.....	.....	.....	.....	0.8068	0.9301
		.....	.....	.....	.....	.....	1.0630

TABLE 5 — Load, in Pounds, Required to Produce Failure of One Rivet in Single Shear
Based on Average Ultimate Shear Strengths Given in Table 2 and Single Shear Areas Given in Tables 3 and 4

Size of Rivet, Inches	COLD DRIVEN							HOT DRIVEN							
	2S	A17S-T3	17S-T3	17S-T31	24S-T31	53S-T61	53S-T6	61S-T6	61S-T31	Annealed Steel	53S-T41 (¹) (960°F.- 980°F)	53S-T41 (¹) (1030°F.- 1050°F)	61S-T43 (990°F.- 1050°F)	877S-T41 (850°F.- 975°F)	Steel
1/8	143	428	505	441	544	298	337	389	311	518	.....	.....	.....	.....	.....
5/32	218	655	775	675	834	457	516	596	477	794	.....	.....	.....	.....	.....
3/16	315	945	1,120	974	1,200	659	745	860	688	1,150	.....	.....	.....	.....	.....
1/4	571	1,710	2,020	1,760	2,180	1,190	1,350	1,560	1,240	2,080	.....	.....	.....	.....	.....
5/16	901	2,700	3,200	2,790	3,440	1,880	2,130	2,460	1,970	3,280	.....	.....	.....	.....	.....
3/8	1,290	3,860	.....	3,980	.....	2,690	3,040	3,510	2,810	4,680	2,230	2,970	2,970	.....	5,450
7/16	1,770	5,320	.....	5,480	.....	3,710	4,190	4,840	3,870	6,450	3,110	4,150	4,150	.....	7,600
1/2	2,300	6,900	.....	7,110	.....	4,810	5,440	6,270	5,020	8,360	3,990	5,320	5,320	8,420	9,750
5/8	2,890	8,660	.....	8,920	.....	6,040	6,820	7,870	6,300	10,500	4,990	6,650	6,650	10,500	12,200
3/4	3,550	10,700	.....	11,000	.....	7,420	8,390	9,680	7,740	12,900	6,080	8,110	8,110	12,800	14,900
7/8	5,070	15,200	.....	15,700	.....	10,600	12,000	13,800	11,100	18,400	8,620	11,500	11,500	18,200	21,100
1	6,860	20,600	.....	.....	.....	14,300	16,200	18,700	15,000	24,900	12,000	16,000	16,000	25,400	29,400
1 1/8	8,920	26,800	.....	.....	.....	18,600	21,100	24,300	19,500	32,400	16,000	21,300	21,300	33,700	39,100

¹See footnote 3 on Table 2.

directly as the number of planes upon which shear occurs, so that in double shear a rivet is twice as strong as in single.

Table 5, page 13, has been prepared to show the loads required to shear individual rivets, as computed from the values of shear strength given in Table 2, page 10. These are ultimate loads and should be used with a suitable factor of safety.

BEARING FAILURE

Bearing failures, in the form of crushing or excessive compressive distortion of the metal, are not easily recognized in rivets themselves. Tests have shown, however, that if a relatively soft rivet is used in a thin plate of harder material, the rivet may fail in shear at a shear stress lower than its normal shear strength determined in tests with thicker plates. Table 6 shows the reduction in shear strength of rivets that occurs

TABLE 6 — Reduction in Shear Strength of Aluminum Alloy Rivets Resulting From Their Use in Thin Plates and Shapes

Ratio of Rivet Diameter to Plate Thickness, ① D/t	Per Cent Loss in Shear Strength		Ratio of Rivet Diameter to Plate Thickness, ① D/t	Per Cent Loss in Shear Strength	
	Single Shear	Double Shear		Single Shear	Double Shear
1.5	0	0	2.8	0	16.9
1.6	0	1.3	2.9	0	18.2
1.7	0	2.6	3.0	0	19.5
1.8	0	3.9	3.1	0.4	20.8
1.9	0	5.2	3.2	0.8	22.1
2.0	0	6.5	3.3	1.2	23.4
2.1	0	7.8	3.4	1.6	24.7
2.2	0	9.1	3.5	2.0	26.0
2.3	0	10.4	3.6	2.4	27.3
2.4	0	11.7	3.7	2.8	28.6
2.5	0	13.0	3.8	3.2	29.9
2.6	0	14.3	3.9	3.6	31.2
2.7	0	15.6	4.0	4.0	32.5

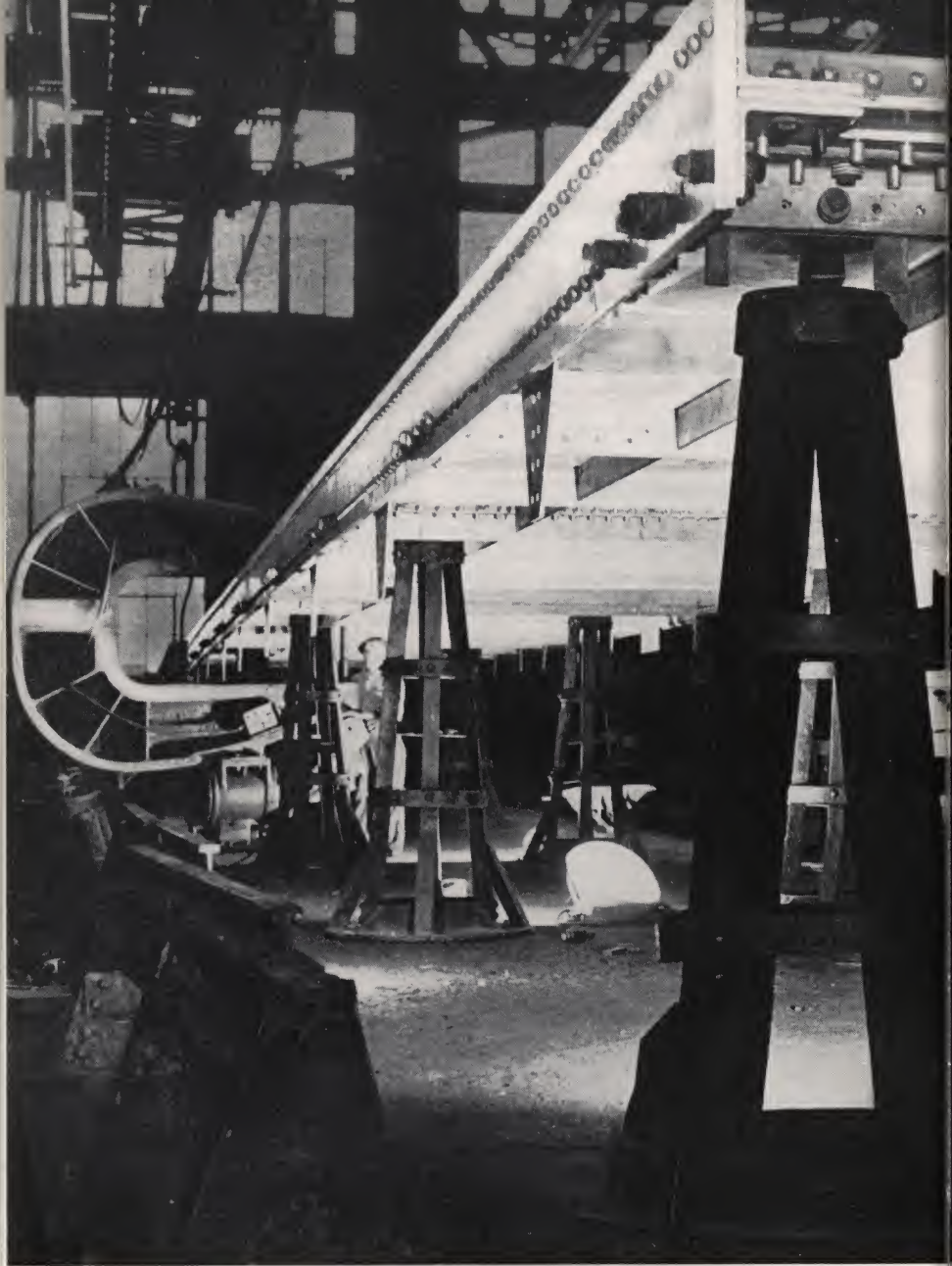
① Thickness of thinnest plate in single shear joint, or of middle plate in double shear joint.

TABLE 7 — Typical Tensile and Bearing Properties
of Aluminum Alloy Plates and Shapes

Alloy	Tensile Properties		Bearing Properties			
			Edge Distance = 1.5 × Rivet Diameter		Edge Distance = 2.0 × Rivet Diameter	
	Ultimate Strength, lb./sq. in.	Yield ^① Strength, lb./sq. in.	Ultimate Strength, lb./sq. in.	Yield ^② Strength, lb./sq. in.	Ultimate Strength, lb./sq. in.	Yield ^③ Strength, lb./sq. in.
2S-O	13,000	5,000	21,000	10,000	27,000	12,000
2S-H12	15,500	14,000	24,000	19,000	30,000	23,000
2S-H14	17,500	16,000	26,000	22,000	32,000	26,000
2S-H16	20,000	18,000	28,000	24,000	34,000	28,000
2S-H18	24,000	22,000	31,000	28,000	38,000	33,000
3S-O	16,000	6,000	25,000	12,000	34,000	15,000
3S-H12	19,000	17,000	28,000	24,000	37,000	27,000
3S-H14	21,500	19,000	31,000	26,000	39,000	31,000
3S-H16	25,000	22,000	34,000	29,000	42,000	35,000
3S-H18	29,000	26,000	38,000	33,000	46,000	40,000
4S-O	26,000	10,000	41,000	18,000	54,000	23,000
4S-H32	31,000	22,000	49,000	31,000	65,000	35,000
4S-H34	34,000	27,000	54,000	38,000	71,000	43,000
4S-H36	37,000	31,000	59,000	44,000	78,000	50,000
4S-H38	40,000	34,000	64,000	47,000	84,000	54,000
14S-T4	62,000	40,000	93,000	56,000	118,000	64,000
Alclad 14S-T4	61,000	37,000	91,000	52,000	116,000	60,000
14S-T6	70,000	60,000	105,000	84,000	133,000	96,000
Alclad 14S-T6	68,000	60,000	102,000	84,000	129,000	96,000
24S-T4	68,000	48,000	102,000	67,000	129,000	77,000
Alclad 24S-T4	64,000	42,000	96,000	59,000	122,000	67,000
24S-T36	72,000	57,000	108,000	80,000	137,000	91,000
Alclad 24S-T36	67,000	53,000	100,000	74,000	127,000	85,000
B50S-O	21,000	8,000	33,000	15,000	44,000	19,000
B50S-H32	24,500	21,000	38,000	29,000	50,000	33,000
B50S-H34	27,500	24,000	42,000	33,000	54,000	38,000
B50S-H36	29,500	26,000	44,000	35,000	56,000	41,000
B50S-H38	31,000	28,000	45,000	37,000	58,000	44,000
52S-O	27,000	12,000	43,000	21,000	57,000	26,000
52S-H32	34,000	27,000	54,000	38,000	71,000	43,000
52S-H34	37,000	31,000	59,000	44,000	78,000	50,000
52S-H36	39,000	34,000	62,000	47,000	82,000	54,000
52S-H38	41,000	36,000	66,000	50,000	86,000	58,000
61S-T4	35,000	21,000	56,000	29,000	73,000	34,000
61S-T6	45,000	40,000	72,000	56,000	94,000	64,000
63S-T5	27,000	21,000	43,000	29,000	57,000	34,000
63S-T6	35,000	31,000	56,000	44,000	73,000	50,000
75S-T6	82,000	72,000	123,000	101,000	156,000	115,000
Alclad 75S-T6	76,000	67,000	114,000	94,000	144,000	107,000

① Tensile yield strength is the tensile stress which produces a permanent set of 0.2 per cent of the initial gage length (American Society for Testing Materials Standard Methods of Tension Testing of Metallic Materials (E8-51T)).

② Bearing yield strength is the bearing stress which produces a permanent set of 2 per cent of the rivet hole diameter.



Squeeze-driving cold rivets in bridge girder.

with increasing ratios of rivet diameter (D) to plate thickness (t). Reduction percentages from this table should be applied to the basic shear strength of a rivet whenever the D/t ratio is large enough to require such a reduction.

Bearing failures of plates or shapes against which rivets bear may occur either by excessive distortion of the metal resulting in progressive elongation of the rivet hole, or by tearing or shearing out a piece of the plate or shape ahead of the rivet. The load at which bearing failure will be encountered may be calculated as follows:

$$\text{Ultimate bearing load per rivet} = f_b \times A_b$$

where f_b = ultimate bearing strength of the metal against which the rivet is bearing, lb. per sq. in.

A_b = area in bearing, sq. in.

Values of ultimate bearing strength, f_b , are given in Table 7. The value of A_b is determined simply by multiplying the diameter of the rivet hole by the thickness of the plate or shape against which the rivet bears.

In considering bearing failures it must be remembered that distortion of the rivet hole may begin at a load considerably less than the ultimate. The bearing stress at which the permanent set in a hole equals 2 per cent of the hole diameter has been adopted as the bearing yield strength of aluminum alloys. Table 7, page 15, shows these bearing yield strengths.

TENSILE FAILURE

Rivets are not well suited for transmitting loads in tension because a slight eccentricity of load exerts a prying action on the head which may result in early failure. This tendency is especially marked under the condition of repeated loads. Consequently, it is generally accepted practice to avoid the use of any connection designed principally for transmitting loads by tension in the rivets. Tensile stresses in rivets cannot

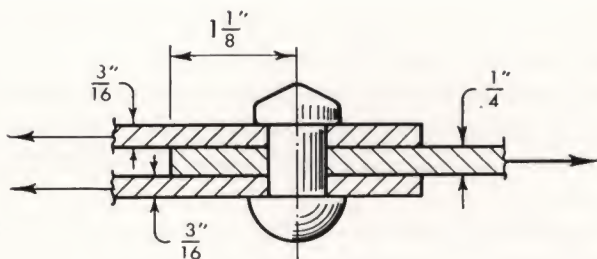
always be avoided because the racking of the framework and other secondary effects may produce appreciable tensile loads, but an effort should always be made to keep such secondary tensile stresses in rivets as low as possible.

FACTOR OF SAFETY

Throughout this discussion, as well as in the tables, ultimate strengths and yield strengths rather than allowable working stresses have been used. For purposes of ordinary design these ultimate and yield values must be divided by a suitable factor of safety. The factor to be used in any given design will depend largely on the judgment of the designer and on his previous experience in similar designs of the same type. In general, the factor of safety to be used in obtaining allowable shear and bearing values of rivets should be consistent with that used in selecting allowable tensile and compressive stresses. For example, if the tensile allowable working stress in a given design is about one-half the tensile yield strength or about one-third the ultimate tensile strength of the material, the allowable bearing value should be selected to bear about these same relations to the bearing yield and bearing ultimate values of the material. In this same example the allowable shear value might be selected as one-third the ultimate shear value of the rivets. Since factors of safety vary considerably in different types of design, no attempt has been made in this booklet to recommend such values or to select a set of allowable working stresses.

Example 1 — Determine the allowable load, using a factor of safety of three on ultimate strength, for a $\frac{1}{2}$ -inch A17S-T3 rivet driven cold in a $\frac{3}{4}$ -inch hole as part of a double butt strap joint in which a $\frac{1}{4}$ -inch 24S-T4 plate is secured between two $\frac{3}{16}$ -inch butt straps. The edge distance in the direction of stressing is $1\frac{1}{8}$ inches. (See drawing on next page.)

The basic single shear strength taken from Table 5, page



13, is 6,900 lb., and the corresponding double shear value is $(2 \times 6,900 =)$ 13,800 lb.

The D/t ratio is $\frac{1/2}{1/4} = 2$. Reference to Table 6, page 14, shows that a reduction in shear strength of 6.5 per cent should be used. Therefore, the actual shear strength is:

$$P_s = (1 - 0.065) \times 13,800 = 12,900 \text{ lb.}$$

The bearing area for the $1/4$ -inch center plate, taken from Table 3, is 0.1290 sq. in.

Since the edge distance in the direction of stressing is not less than twice the hole diameter, the ultimate bearing strength of the plate from Table 7, page 15, is:

$$f_b = 129,000 \text{ lb. per sq. in.}$$

The load required to produce bearing failure is therefore

$$P_b = 129,000 \times 0.1290 = 16,640 \text{ lb.}$$

Comparing the values of P_s and P_b and selecting the smaller of the two, the load required to produce failure of the rivet is found to be 12,900 lb. Dividing this ultimate load by the factor of safety, the following allowable load is obtained:

$$\text{Allowable load} = \frac{12,900}{3} = 4,300 \text{ lb.}$$

Example 2 — Determine the allowable load in the foregoing example if the edge distance in the direction of stressing had been $3/4$ inch instead of $1 1/8$ inches and the factor of safety

had been three with respect to ultimate or two with respect to yield, whichever gives the smaller value.

Since the edge distance is 1.5 times the rivet diameter, the ultimate bearing strength and bearing yield strength for the plate, taken from Table 7, page 15, are 102,000 and 67,000 lb. per sq. in.

The allowable shear value of the rivet based on a factor of safety of three on ultimate is the same as in the preceding example, 4,300 lb.

The allowable bearing value of the rivet based on a factor of safety of three on ultimate is

$$102,000 \times 0.1290 \times \frac{1}{3} = 4,390 \text{ lb.}$$

The allowable bearing value of the rivet based on a factor of safety of two on yield is

$$67,000 \times 0.1290 \times \frac{1}{2} = 4,320 \text{ lb.}$$

The lowest of these three values, 4,300 lb., is the allowable value of the rivet in this example. Note that it is the same as the allowable value in the previous example.

FATIGUE STRENGTH

Experience has indicated that structures subjected to repeated loads sometimes fail in fatigue at lower stresses than would be expected under steady load. Such fatigue failures are often associated in some way with the joints in the structure, because the joints usually represent points of weakness both from the standpoint of reduced section of the members and from the standpoint of stress concentration. In a riveted structure a shear fatigue failure of a rivet is very seldom encountered, because there seems to be a much greater tendency for tensile fatigue fracture of the shapes and plates starting at the rivet holes. These tensile fatigue fractures result from the fact that the rivet holes, like other discontinuities that may be present in a structure, produce concentrations of stress which have little or no effect on the strength of the structure under

steady load but which cause cracks to start under many repetitions of load.

The design of a joint to resist fatigue action is complicated by the many factors involved, such as the magnitude of the average stress, the degree of stress concentration, the fatigue strength of the material, the relation of the average stress to the variable stress, the number of repetitions of stress, and the type and arrangement of rivets. A few observations based on investigations that have been under way for sometime at Aluminum Research Laboratories, may be helpful:

1. A hole well filled with a rivet causes less reduction of the fatigue strength of a structure than an open hole.
2. The reduction of the fatigue strength of a structure is greater for a rivet carrying stress than for a stitch rivet.
3. The reduction of the fatigue strength of a structure is greater for hot-driven steel rivets than for cold-driven steel rivets or aluminum alloy rivets, driven either hot or cold.
4. Lap joints reduce the fatigue strength of a structure more than butt joints with double straps. This greater effect seems to be associated with the greater flexing which occurs in the lap joint. Any stiffening of the lap joint to prevent undue flexing under repeated loads tends to improve the fatigue characteristics of the joint.
5. The geometry of a joint is much more important in governing its fatigue strength than is the choice of alloys. Stress concentrations should be alleviated by avoiding sharp re-entrant corners and by using generous fillets and smooth transitions. Secondary bending should be minimized.



Cold Upsetting $\frac{7}{8}$ -In. Diameter Rivets in a Squeeze Riveter. These rivets were ordered as A17S-T4. Cold work during driving hardens such rivets so that after driving the designation is changed to A17S-T3.

PROPORTIONS OF RIVETED JOINTS

THE first requirement of riveted joints is that they be strong enough to transfer safely the forces acting on the parts joined. This requirement determines only in a general way the design of the joint, because a number of joints can be designed for any given case, all strong enough, but varying widely in size and spacing of rivets. In the following paragraphs, the factors influencing the proportions of riveted joints are discussed. Such factors will be found helpful in laying out highly stressed joints, as well as those in which the rivets are used simply to fasten two or more parts together.

SIZE OF RIVET; MAXIMUM AND MINIMUM LIMITS

If a large rivet is used in thin metal, the bearing strength usually governs and there is an excess of shear strength. Moreover, the pressure required to drive the large rivet frequently causes an undesirable bulging of the thin material around the rivet head. For these reasons, the diameter of the rivet should not exceed three times the thickness of the sheet or plate.

On the other hand, if a small rivet is used in a thick plate, the shear strength is the determining factor and there is an excess of bearing strength. Small holes in thick plate usually make fabrication difficult. Experience indicates that the rivet diameter should not be less than the thickness of the thickest plate through which it is driven.

SPACING OF RIVETS

The spacing of rivets in any joint ordinarily depends upon the proportions of the members joined. The minimum spacing is determined by driving conditions; the space between the rivets must be sufficient to permit them to be driven without

interference. Three times the nominal rivet diameter is the recommended minimum spacing. In tension members and joints, the spacing must be such that the net stressed area is not too small. In some cases this becomes the controlling consideration.

The maximum spacing of rivets in compression members may be governed by the possibility of the buckling of the component parts between rivets. In other types of members, the maximum spacing is determined usually by the designer's sense of proportion, especially when the rivets are used simply to hold two or more plates or shapes together. As a rule, it is recommended that the maximum distance be not greater than twenty-four times the thickness of the sheet or plate.

EDGE DISTANCE

It already has been said that for maximum bearing strength, the edge distance measured from the center of the hole in the direction of stressing should be at least twice the diameter of the rivet and that the allowable bearing stress is decreased if the edge distance is less than this amount. Aside from considerations of strength, the edge distance is important because of the possibility of bulging the edge of the plate, thus causing an unsightly finished joint. Such bulging may be avoided ordinarily by maintaining an edge distance of at least one and one-half times the diameter of the rivet and being careful to avoid overdriven rivets. When cold steel rivets are used, a minimum edge distance of two diameters should be maintained. If edge distances less than those indicated above are used, the rivets generally must be underdriven to avoid bulging the plate.

CALKED JOINTS

Riveted joints which must be pressure-tight may be calked either by deforming the edges of the plates with a calking

tool or by using calking strips of a softer alloy to seal the joint. Joints which are to be calked by either of these methods should have edge distances about one and one-half times the rivet diameter or about four times the thickness of plate. The spacing of rivets should not exceed four times the rivet diameter nor about ten times the thickness of plate.

In some types of riveted joints where it is not convenient to calk in the way described, the joint often can be made pressure-tight simply by packing it with a material to act as a seal. It is important that such a material be nonabsorbent, firm enough so it will not "bleed" through the joint, and over a period of time, tough enough not to crack or spall. Such packing materials should be noncorrosive to aluminum and should be applied in layers thin enough not to affect appreciably the strength of the joint.



Hot Driving Rivets With Pneumatic Hammer. These rivets were ordered as 53S-T4. Hot driving alters their properties so that the final designation is 53S-T41.

DRIVING METHODS FOR RIVETED JOINTS

THE driving methods for riveted joints in aluminum alloy construction do not differ greatly from those used for other metals. Because the characteristics of the various materials used for rivets differ, there is some difference in the driving methods employed for rivets made from each of the aluminum alloys as well as those made from steel. These differences are explained in the following paragraphs:

2S-F RIVETS

These relatively soft rivets always are driven cold, as received. They may be stored indefinitely without affecting their strength or driving characteristics.

A17S-T4 RIVETS

Rivets of A17S-T4 always are furnished in the heat-treated condition and are driven cold as-received. They eliminate some of the extra operations required for 17S rivets, such as frequent heat treatment and cold storage. After driving, these rivets are designated A17S-T3. While the strength of driven A17S-T3 rivets is not equal to that of 17S-T31 rivets (Table 2), they are so nearly alike in strength that the A17S-T3 rivets have been found satisfactory for many uses, particularly in aircraft work. Rivets of A17S-T4 may be stored indefinitely with no change in properties.

17S-T4 RIVETS

Alloy 17S rivets are furnished in the heat-treated condition and in small sizes can be driven cold as-received without re-heat treatment. To make the rivets easier to drive, however,

TABLE 8 — Pressures Required to Drive Cone-Point
Rivets with Squeeze Riveter

Temper designations used in this table are for driven rivets.

Pressures given are for complete cone-point heads as dimensioned in Figure 2.

Size, inch	Pressures for Cold-Driven Rivets, in Tons										Pressures for Hot- Driven Rivets, in Tons			
	2S-F	A17S- T3	17S- T3	17S- T31	24S- T31	53S- T61	53S- T6	61S- T31	61S- T6	An- neal- ed Steel	53S- T41 960°- 1050°F.	61S- T43 990°- 1050°F.	B77S- T41 850°- 975°F.	Steel 1700°- 1900°F.
3/16	1	3	..	..	..	2	..	..	2	..	..	..	..	..
1/4	2	5	6	5	6	3	3	3	4	6	..	..	..	2
5/16	5	10	..	11	..	7	8	6	9	13	..	..	..	3
1/2	9	18	..	20	..	12	14	11	16	23	4	4	5	4
5/8	13	28	..	31	..	19	21	16	25	35	5	5	6	5
3/4	18	41	..	44	..	28	30	23	37	51	6	6	7	6
7/8	26	56	..	60	..	38	41	32	50	69	8	8	9	8
1	34	73	..	78	..	50	54	42	65	90	10	10	11	10

TABLE 9 — Pressures Required to Drive Button
Head Rivets with Squeeze Riveter

Pressures given are for complete button heads as dimensioned in Figure 1, Number 1, for sizes smaller than 1/2-inch and as dimensioned in Figure 3 for sizes 1/2-inch and larger.

Size, inch	Pressures for Cold-Driven Rivets, in Tons					Pressures for Hot-Driven Rivets, in Tons			
	2S-F	A-17S- T3	17S-T31 ①	53S-T61	53S-T6	53S-T41 960°- 1050°F.	61S-T43 990°- 1050°F.	B77S-T41 850°- 975° F.	Steel 1700°- 1900°F.
3/16	3	6	..	4	..	..	..	..	..
1/4	6	10	10	8	9	..	..	..	10
5/16	14	23	24	16	18	12	12	..	17
1/2	25	39	42	30	31	21	21	24	25
5/8	34	56	60	45	47	27	27	30	30
3/4	45	..	..	65	..	35	35	38	36
7/8	58	..	..	..	..	44	44	47	42
1	..	..	..	..	..	53	53	56	49

① Driven immediately after quenching.

17S-T4 rivets are usually reheat-treated just prior to use. After being driven in this manner, the rivets are designated 17S-T3. The heat treatment consists of holding the rivets at a temperature of 930°F to 950°F for from 5 to 30 minutes, depending on the size and number, and then quenching immediately in cold water. Following this treatment, the rivets harden gradually at room temperature, obtaining their full strength in about four days. During the first one or two hours after quenching, the rivets are relatively soft and may be driven cold in sizes that are limited by the shape of head and equipment available, as shown by Tables 8 and 9. After being so driven the rivets are designated 17S-T31.

If 17S-T4 rivets are allowed to age more than two hours at room temperature after quenching, they are often too hard to drive and must again be heat treated. Heat treatment may be repeated as often as desired without injury to the rivets, provided the heat treating temperature is carefully maintained in the indicated range. The aging can be retarded considerably by storing the quenched rivets at low temperatures. Rivets stored at 32°F immediately after quenching remain soft enough for driving for about 36 hours. By using solid CO₂ (Dry Ice) or mechanical refrigeration, much lower storage temperatures can be maintained and the driving period prolonged almost indefinitely. At a temperature of -50°F, for example, rivets remain soft enough for driving for a period of two weeks or more.

24S-T4 RIVETS

These rivets, although very strong, are quite difficult to drive and are used only in the smaller sizes. They are supplied heat treated but should be reheat treated and either used immediately or refrigerated as described for 17S rivets. The heat-treating temperature range is 910°F to 930°F. After driving, the rivets are designated 24S-T31.



Driving 61S-T31 rivets with pneumatic hammer in aluminum deckhouse assembly. Riveted aluminum superstructure and stack of the S.S. "United States" in background.

53S RIVETS

Rivets of alloy 53S may be obtained in several different tempers. The one most often used is 53S-T61, and in this temper the rivets may be driven cold, as received. They may be stored indefinitely without change in strength or driving characteristics. The rivets are also supplied in the 53S-T6 temper which may also be stored indefinitely without change in strength or driving characteristics. In this temper the rivets are somewhat harder to drive and consequently are less frequently used.

Rivets for hot driving may be ordered in any temper, 53S-F, 53S-T4, 53S-T61, or 53S-T6. Rivets of 53S-F are cheapest but have the disadvantage of being so soft that they might be driven cold by mistake, which would result in a very weak rivet. The recommended temper for hot driving is 53S-T4. The rivets are heated at a temperature from 960°F to 1050°F for about 15 minutes and are then inserted in the hole and driven. Control of the heating temperature range from 1030°F to 1050°F assures higher shear strengths, as indicated in the footnote in Table 2, page 10. Quench of the rivets is obtained by contact with the relatively cold metal around the hole and driving tools. It is important that the rivet be driven without any delay after it is removed from the furnace to assure ease of driving. After hot driving the rivets are designated 53S-T41.

61S RIVETS

Rivets of 61S-T6 are driven cold, as received, although in the larger sizes this generally requires squeeze-driving equipment. They may be stored indefinitely without change in strength or driving characteristics.

A considerable reduction of driving pressure is obtained by driving 61S rivets in the freshly quenched condition. The rivets are ordered in the T4 condition and are then reheat-

treated just before they are used. The heat-treatment consists of holding the rivets at a temperature of 1030°F to 1050°F for 10 to 30 minutes, depending on the size and number, and then quenching immediately in cold water. Following this treatment the rivets harden gradually at room temperature but can be readily driven during the first hour or two after quenching. After being so driven, the rivets are designated 61S-T31. The hardening of the rivets can be retarded by refrigerating the freshly quenched rivets as was described on page 29 for 17S rivets.

Rivets of this alloy may also be driven hot using a temperature range of 990°F to 1050°F. For this purpose they are ordered in any desired temper, although, as in the case of 53S, the recommended temper is that designated as 61S-T4. The shear strength of the 61S rivets, unlike that of 53S rivets, is not appreciably affected by the driving temperature. After hot driving, the rivets are designated 61S-T43.

B77S-T4 RIVETS

The quest for a high strength aluminum alloy for large-diameter, hot-driven rivets has resulted in the development of alloy B77S by Aluminum Company of America. Rivets of this alloy are heated in air for about 15 minutes at 850°F to 975°F. Heating above this temperature range may result in head cracking and impaired resistance to corrosion. Little variation in shear strength results when these rivets are driven within the specified temperature range. The driving pressures for B77S rivets in Tables 8 and 9, page 28, were obtained in the upper part of the temperature range; higher driving pressures can be expected in the lower part of the range. It is important that these rivets be driven as soon as possible after heating to assure ease of driving.

B77S rivets are always furnished in the -T4 temper, i.e., solution heat treated and quenched. This treatment is em-

played to facilitate the complete solution of the alloying elements when reheated for driving. These rivets may be hot driven only and in the driven condition are designated B77S-T41.

Cold driving B77S rivets is definitely not recommended.

STEEL RIVETS

Steel rivets, when properly annealed by heating to about 1300° F and cooling slowly in the furnace, make very satisfactory rivets for cold driving. In the larger sizes, squeeze-driving equipment is necessary to upset the rivets properly.

Steel rivets may also be driven hot in aluminum alloy structures. They are heated to about 1800°F and driven with as little delay as possible so as to make the driving easier.

Where a large group of hot steel rivets are to be driven closely spaced, it is necessary to avoid overheating the adjacent metal. Generally, it is sufficient to drive at random rather than in succession. Sometimes it may be necessary to cool by water or compressed air, preferably the latter. The temperature of the aluminum alloy parts never should be

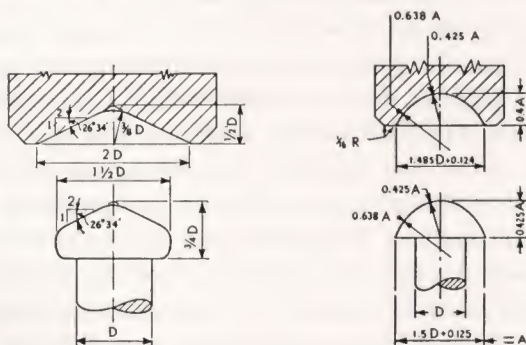


FIGURE 2 (left). Nominal dimensions of cone-point head and rivet set.

FIGURE 3 (right). Nominal dimensions of American Standard driven button head and rivet set for sizes 1/2 inch and larger. This rivet set is also used as a bucking tool for American Standard high button head, Figure 1, No. 2, page 6.

allowed to rise above 400°F. For alloy 17S and 24S the temperature should not be allowed to exceed 300°F. If these precautions are taken, the strength of the parts will not be affected appreciably and warping will be reduced to a minimum. The use of hot driven steel rivets in aluminum alloy structures is usually confined to locations where the aluminum alloy is being riveted to steel parts.

PRESSURES REQUIRED TO DRIVE

The pressure required to drive a rivet depends upon the size, the type of driven head, the rivet material and the driving temperature. It varies roughly as the square of the diameter of the finished driven head, so that a small driven head has a considerable advantage over a larger one. Tests have shown that very small heads are sufficient to develop the strength of the rivet shank, even when the rivets are subjected to straight tensile pull. Therefore, where ease of driving is important and where a large head size is not needed for appearance or other reasons, the smaller sizes of driven heads should be used to decrease the required driving pressure.

After considerable research on the factors influencing driving pressure, the cone-point type of driven head shown in Figure 2, page 33, has been developed for use on aluminum alloy rivets. This head is large enough to develop the tensile strength of the rivet shank in a straight tensile pull, and yet is so small that it requires much less driving pressure than a full button head, as indicated by a comparison of Tables 8 and 9, page 28. The cone-point head has the additional advantage of requiring less stock, as indicated by a comparison of Tables 11 and 12, pages 38 and 39, and it is not greatly affected in appearance by slight variations in length of shank. Several sizes of rivets may be driven with a given cone-point rivet set, when the set is made as illustrated in Figure 2, page 33. Some users have found, however, that when using the set

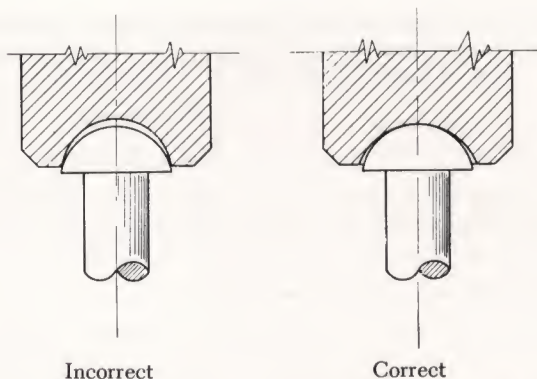


FIGURE 4. Showing the incorrect and correct fit of the bucking tool on the manufactured head (clearances exaggerated).

with a pneumatic hammer it is advantageous to extend the edges of the set in the form of a slightly flared shallow skirt to help center the set on the rivet shank and prevent drifting. Under these circumstances, of course, a different set is required for each size of rivet.

The degree of upsetting for cone-point head rivets is best controlled by checking the diameters of the driven heads and keeping these as close as possible to 1.5 times the nominal shank diameter. If the rivets are cut to the correct length (Table 11, page 38) and the diameter of the driven head is controlled, the other head dimensions will require no attention.

The cone-point head is used only as a driven head and is not available as a manufactured head. It can be used, however, with any of the manufactured heads shown in Figure 1, pages 6 and 7, and it is recommended in all cases when other considerations do not require the use of some other driven head. If a more rounded head is needed, the button head should be used since it is the smallest head of this type. For sizes smaller than $\frac{1}{2}$ inch the driven button head may conform to the shape of manufactured head No. 1 shown in Fig-

TABLE 10 — Smallest Sizes of Pneumatic Hammers Considered Satisfactory For Driving Aluminum Alloy Rivets Based on Actual Driving Tests With 90 Psi Air Pressure

Rivet Size, inch	Cone Point Heads									Cone Point Heads			Button Heads		
	Cold									Hot			Hot		
										53S- T41 960- 1050°F	61S- T43 990- 1050°F	877S- T41 850- 975°F	53S- T41 960- 1050°F	61S- T43 990- 1050°F	877S- T41 850- 975°F
	2S-F	A17S- T3	17S- T3	17S- T31	24S- T31	53S- T61	53S- T6	61S- T31	61S- T6						
3/16	A	A	..	..	..	A	..	..	A	..	..	..	..	..	..
1/4	A	B	B	B	B	A	B	A	B	..	..	..	..	..	..
3/8	B	C	..	C	..	C	C	C	C	..	..	..	..	..	..
1/2	C	E	..	F	..	D	E	D	E	C	C	C	E	E	E
5/8	D	G	..	G	..	F	F	E	G	C	C	E	F	F	..
3/4	E	..	..	..	..	G	G	F	..	D	D	G	G	G	..
7/8	G	..	..	..	..	..	..	..	..	F	F	G	..	..	..
1	..	..	..	..	..	..	..	..	..	G	G	..	..	..	..

Key to Hammer Sizes Indicated Above

Hammer	Bore, in.	Stroke, in.	Hammer	Bore, in.	Stroke, in.
A	1/2	4 7/16	E	1 1/16	8
B	1 1/8	3	F	1 3/16	8
C	1 1/16	4	G	1 3/16	11
D	1 1/16	6			

ure 1, pages 6 and 7, but for sizes 1/2 inch and larger, the driven button head should conform to the dimensions shown in Figure 3, page 33. Care should be taken to avoid confusing the round head with the button head (No. 3 and No. 1 in Figure 1, pages 6 and 7) because, although they look somewhat alike, the round head is larger and hence harder to drive.

Tables 8 and 9, page 28, give pressures required to drive button heads and cone-point heads with a squeeze riveter. These tables may be used as a guide in comparing the driving characteristics of the different rivets and in selecting the proper equipment for driving.

Excessive pressures used in driving may result in any or all of the following difficulties: bulging of the edge of the piece being riveted, buckling or other distortion, particularly if thin material is being used, and weakening or fracturing of

metal adjacent to the hole. Overdriving of rivets should always be avoided.

RIVETING EQUIPMENT

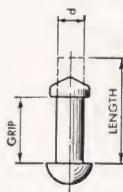
Squeeze riveters generally are preferable to other types for driving rivets in aluminum. Their use assures properly upset shanks and well-centered heads. A squeeze riveter is essentially a press that upsets and forms a head on a rivet by steady pressure rather than by repeated blows. The capacity required for a squeeze riveter may be determined by reference to Tables 8 and 9, page 28.

Pneumatic hammers are suitable for riveting aluminum alloy structures, provided they are large enough to upset the rivets properly. It is difficult to give explicit instructions on sizes of hammers required but the information in Table 10 may be used as a guide. These data are based on driving tests with seven sizes of hammers using both vertical and horizontal driving positions. Hammer sizes selected on the basis of this table should be checked by actual driving tests using conditions encountered on the particular job under consideration.

Aluminum alloy rivets may be headed by means of a heavy hand hammer or sledge, provided that the work permits adequate bucking.

Rivet sets for use on aluminum alloy rivets should have smooth, polished surfaces so that the metal may flow readily during the forming of the head. The bucking tools, especially those used with the larger hammers, should have plenty of mass. The mass should be distributed close to the rivet head, and be concentric with it. The cup on the bucking-up set should be slightly wider and shallower than the manufactured head, so that the initial contact will be at the end of the head directly in line with the shank, as shown in Figure 4, page 35. This practice will prevent the shank from being

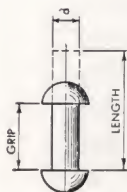
TABLE 11 — Lengths of Rivets for Cone-Point Driven Heads
Cone-Point Heads Are Dimensioned in Figure 2



Grip	For Hole Diameters Not More Than $\frac{1}{32}$ Inch Greater Than Rivet Diameters								For Hole Diameters $\frac{1}{16}$ Inch Greater Than Rivet Diameters					
	$d = \frac{1}{4}$	$d = \frac{5}{16}$	$d = \frac{3}{8}$	$d = \frac{1}{2}$	$d = \frac{5}{8}$	$d = \frac{3}{4}$	$d = \frac{7}{8}$	$d = 1$	$d = \frac{1}{2}$	$d = \frac{5}{8}$	$d = \frac{3}{4}$	$d = \frac{7}{8}$	$d = 1$	
$\frac{1}{8}$	$\frac{7}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{13}{16}$	$\frac{15}{16}$	1	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{11}{16}$	$\frac{13}{16}$	1	$\frac{1}{8}$	$\frac{1}{4}$	
$\frac{1}{4}$	$\frac{13}{16}$	$\frac{5}{8}$	$\frac{11}{16}$	1	$\frac{15}{16}$	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{13}{16}$	$\frac{1}{8}$	1	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{1}{2}$	
$\frac{3}{8}$	$\frac{15}{16}$	$\frac{13}{16}$	$\frac{7}{8}$	1	$\frac{15}{16}$	$\frac{13}{16}$	$\frac{1}{2}$	$\frac{15}{8}$	$\frac{13}{16}$	$\frac{15}{16}$	$\frac{7}{8}$	$\frac{1}{2}$	$\frac{15}{8}$	
$\frac{1}{2}$	1	1	1	$\frac{1}{8}$	$\frac{15}{16}$	$\frac{13}{16}$	$\frac{1}{2}$	$\frac{15}{8}$	$\frac{13}{16}$	$\frac{15}{16}$	$\frac{7}{8}$	$\frac{1}{2}$	$\frac{15}{8}$	
$\frac{5}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{3}{4}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{7}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
1	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{11}{16}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{13}{16}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{15}{16}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{1}{8}$	...	...	...	$\frac{15}{8}$	2	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{1}{4}$	...	...	...	2	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{3}{8}$	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{1}{2}$	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{5}{8}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{3}{4}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{7}{8}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
1	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{11}{16}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{13}{16}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{15}{16}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{1}{8}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{1}{4}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{3}{8}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{1}{2}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{5}{8}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{3}{4}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{7}{8}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
1	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{11}{16}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{13}{16}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{15}{16}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{1}{8}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{1}{4}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{3}{8}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{1}{2}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{5}{8}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{3}{4}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{7}{8}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
1	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{11}{16}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{13}{16}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{15}{16}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{1}{8}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{1}{4}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{3}{8}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{1}{2}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{5}{8}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{3}{4}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{7}{8}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
1	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{11}{16}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{13}{16}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{15}{16}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{1}{8}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{1}{4}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{3}{8}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{1}{2}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{5}{8}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{3}{4}$	...	...	...	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	$\frac{15}{8}$	
$\frac{7}{8}$														

TABLE 12 — Lengths of Rivets for Button Driven Heads

Button driven heads are dimensioned in Figure 1, No. 1, for sizes smaller than $\frac{1}{2}$ inch and are dimensioned in Figure 3 for sizes $\frac{1}{2}$ inch and larger.



Grip	For Hole Diameters Not More Than 1/32 Inch Greater Than Rivet Diameters							For Hole Diameters 1/16 Inch Greater Than Rivet Diameters						
	d = 1/4	d = 5/16	d = 3/8	d = 1/2	d = 5/8	d = 3/4	d = 7/8	d = 1	d = 1 1/2	d = 5/8	d = 3/4	d = 7/8	d = 1	
1/8	9/16	5/8	3/4	...	...	...	...	...	...	...	...	...	...	
1/4	3/4	13/16	7/8	1	1 3/16	1 3/8	1 1/2	1 3/4	1 1/4	1 1/4	1 1/2	1 5/8	...	
3/8	1 1/8	1 1/4	1 1/2	1 3/8	1 1/2	1 5/8	1 3/4	1 7/8	1 3/4	1 3/8	1 1/2	1 3/4	1 3/4	
1/2	1 1/4	1 1/2	1 3/4	1 1/2	1 5/8	1 3/4	1 7/8	2	1 1/2	1 3/4	1 3/4	1 3/4	1 7/8	
5/8	1 3/8	1 1/4	1 1/2	1 1/2	1 5/8	1 3/4	1 7/8	2	1 1/2	1 3/4	1 3/4	1 3/4	2	
3/4	1 3/8	1 1/4	1 1/2	1 1/2	1 5/8	1 3/4	1 7/8	2 1/8	1 1/2	1 3/4	1 3/4	1 3/4	2 1/4	
7/8	1 1/2	1 1/4	1 1/2	1 1/2	1 5/8	1 3/4	1 7/8	2 1/4	1 1/2	1 3/4	1 3/4	1 3/4	2 1/2	
1	1 3/4	1 1/2	1 1/2	1 1/2	1 5/8	1 3/4	1 7/8	2 3/8	2	1 3/4	1 3/4	1 3/4	2 1/2	
1 1/8	...	1 1/2	2	2 1/8	2 3/8	2 1/2	2 3/4	2 1/2	2 1/4	2 3/8	2 1/2	2 3/8	2 3/4	
1 1/4	...	2 1/8	2 1/8	2 1/4	2 3/8	2 1/2	2 3/4	2 1/2	2 3/8	2 1/2	2 3/8	2 3/4	2 3/8	
1 3/8	...	...	2 3/8	2 1/2	2 3/8	2 1/2	2 3/4	2 1/2	2 3/8	2 1/2	2 3/8	2 3/4	2 3/8	
1 1/2	...	...	2 1/2	2 1/2	2 1/2	2 1/2	2 3/4	3	2 3/4	2 1/2	3	3	3	
1 5/8	...	...	...	2 1 1/8	2 1 1/8	2 1 1/8	3	3 1/8	2 7/8	3	3 1/8	3 1/8	3 1/4	
1 3/4	...	...	...	2 7/8	2 1 5/8	3 1/8	3 1/8	3 1/4	3 1/8	3 1/8	3 1/4	3 1/4	3 3/8	
1 7/8	...	...	...	3	3 1/8	3 1/4	3 1/4	3 3/8	3 1/4	3 3/8	3 3/8	3 1/2	3 1/2	
2	...	...	...	3 3/8	3 1/4	3 3/8	3 3/8	3 1/2	3 3/8	3 1/2	3 1/2	3 3/8	3 3/8	
2 1/8	...	...	...	...	3 3/8	3 1/2	3 1/2	3 3/8	...	3 3/8	3 3/8	3 3/4	3 3/8	
2 1/4	...	...	...	...	3 3/8	3 3/4	3 3/4	3 3/4	...	3 3/4	3 3/4	4	4	
2 3/8	...	...	...	...	3 3/4	3 3/4	3 3/4	3 3/4	...	3 3/4	3 3/4	4 1/8	4 1/8	
2 1/2	...	...	...	...	3 7/8	3 7/8	3 7/8	4	...	4	4 1/4	4 1/4	4 1/4	



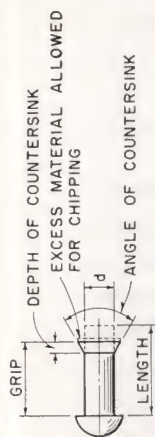
Hot driving rivets heated in an air furnace with automatic temperature regulation and circulating atmosphere.

driven up into the head, and will greatly facilitate uniform upsetting throughout the length of the shank.

In the case of high button-head rivets (No. 2 in Figure 1, pages 6 and 7), the bucking set should have the same dimensions as the driving set illustrated in Figure 3, page 33. When this bucking set is held against the manufactured head, the initial contact is in the proper position as outlined above, and furthermore, the shape of the manufactured head will be altered during driving so that after the rivet is driven, the

TABLE 13 — Lengths of Rivets for Countersunk Driven Heads
Countersunk Heads are dimensioned as shown below (U. S. Navy Standard).

Lengths given include an allowance for chipping, the average thickness of which will be about one-eighth the nominal rivet diameter. Lengths are based on hole sizes shown in Tables 3 and 4.



Angle of csk.	Cold Driven				Hot Driven			
	78°	78°	60°	60°	60°	60°	60°	60°
Depth of csk., in.	1/8	5/32	3/16	7/32	3/16	7/32	5/16	11/32
Rivet Diameter, in.	d = 5/16	d = 5/8	d = 1/2	d = 5/8	d = 1/2	d = 5/8	d = 3/4	d = 7/8
1/4	1/2	9/16	1/2	1/2	1/2	9/16	....	....
3/8	5/8	1 1/16	5/8	1 1/16	1 1/16	1 1/16	13/16	....
1/2	3/4	1 3/16	3/4	1 3/16	1 3/16	1 3/16	1 5/16	1 1/16
5/8	7/8	1 5/8	7/8	1 5/8	1 5/8	1 5/8	1 1/2	1 3/8
3/4	1	1 7/8	1	1 7/8	1 7/8	1 7/8	1 1/4	1 5/8
7/8	1 1/4	1 5/4	1 3/4	1 5/4	1 3/4	1 5/4	1 3/4	1 1/2
1	1 1/2	1 7/4	1 5/4	1 7/4	1 5/4	1 7/4	1 1/2	1 5/8
1 1/8	1 7/8	1 7/2	1 7/8	1 7/8	1 7/8	1 7/8	1 5/8	1 3/4
1 1/4	1 9/8	1 5/2	1 7/8	1 5/2	1 7/8	1 5/2	1 3/4	1 7/8
1 3/8	....	1 3/4	1 11/16	1 3/4	1 13/16	1 3/4	1 5/8	2
1 1/2	....	1 7/8	1 13/16	1 7/8	1 13/16	1 13/16	2	2 1/8
1 5/8	....	....	2	2 1/8	1 5/8	2 1/8	2 1/8	2 3/8
1 3/4	....	....	2 1/8	2 1/8	2 1/8	2 1/8	2 3/8	2 5/8
1 7/8	....	....	2 1/4	2 1/4	2 1/4	2 1/4	2 5/8	2 7/8
2	....	....	2 1/4	2 3/8	2 3/8	2 3/8	2 5/8	2 3/4
2 1/8	....	....	2 3/8	2 1/2	2 1/2	2 1/2	2 5/8	2 3/4
2 1/4	....	....	2 3/8	2 5/8	....	2 5/8	2 11/16	2 7/8
2 1/2	....	....	2 3/4	2 3/4	....	2 3/4	2 13/16	3
2 3/8	....	....	2 7/8	2 7/8	....	2 7/8	3	3 1/8
2 1/2	....	....	2 7/8	3	....	3	3 1/8	3 3/8

GRIP, IN.

shape of the manufactured head will conform to that of the driven button head.

For heat treating aluminum alloy rivets, a reliable temperature indicator is essential in order to insure the required temperature control. When rivets are to be quenched in water for cold driving, the heating equipment generally consists of a bath of sodium nitrate heated by gas, oil or electricity. Steel tubes closed at one end are immersed in the nitrate with the open end projecting slightly and fitted with a readily removable cap. The rivets are placed inside these tubes to prevent them from touching the nitrate, and are heated for about one-half hour. At the end of the heat-treatment period, the cap is removed, the tube taken quickly from the bath and the rivets immediately poured from the container into cold water. Electrically heated air furnaces may also be used for heat treating aluminum alloys, but care should be taken to have the temperature uniform throughout such a furnace.

Aluminum alloy rivets for hot driving can best be heated in an air furnace with a circulating atmosphere to insure uniform temperature distribution and rapid temperature rise. Special furnaces for rivet sizes $\frac{3}{8}$ inch to 1 inch diameter have been used in shop work as shown in the picture on page 40.

RIVET HOLES

Rivet holes in aluminum alloys may be punched, drilled, or sub-punched and reamed to size. The last method is preferable, especially if the reaming is done in assembly to give the holes exact coincidence. It has been found that bridge reamers of the spiral-fluted type are best suited for use in aluminum and aluminum alloys.

The clearance which is to be allowed in the holes depends largely on the class of work. It is easier to drive rivets, especially those cold driven, when the clearance is small. If a



Driving aluminum alloy rivets with cone-point heads

loose fit is used, it will be hard to hold the rivets straight, and eccentric heads often result. The best clearance is the smallest one which will allow the rivet to be inserted easily without delay. Hot rivets require more clearance than cold ones because it is harder to handle them and delay in inserting them in the holes must be minimized.

Rivet holes tend to get out of coincidence during the driving operation because of slippage, swelling of the metal, and warping caused by heat. For this reason, the work should be assembled firmly by bolts before driving. The bolting should be tight to prevent slippage and to prevent the rivets from squeezing out between the parts of the joint.

LENGTHS OF RIVETS

The length of rivet required for forming a head depends upon the grip or total thickness of metal through which the rivet is driven, clearance between rivet and rivet hole, and the form of head. Tables 11, 12 and 13, pages 38, 39 and 41, give the approximate lengths for various grips for three types of driven heads. Because of variations in rivet sets and driving conditions, it is recommended that several trials be made with the equipment to be used before specifying the exact length of rivets. It is better to have the rivets slightly too long, because a short rivet may allow the rivet set to strike and damage the plate.

It should be noted that the lengths of rivets for countersunk driven heads given in Table 13, page 41, include an allowance for chipping. It is virtually impossible to adjust the rivet length and to drive a countersunk head so that the driving operation alone gives a head flush with the surface of the work. Good practice calls for a length of rivet which will leave some metal standing above the surface at the conclusion of the driving operation to insure complete filling of the countersunk hole and to avoid damage to the surrounding plate material. Where absolute flushness is not required the excess material can be permitted to remain, but on most work a chipping or grinding operation is performed after the driving of the rivet is completed. Chipping should be done only with a very sharp chipping tool.

SELECTION OF RIVET ALLOY

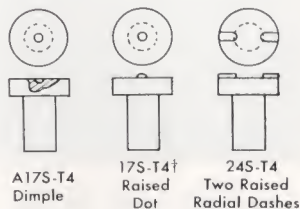
It is poor practice to use a hard rivet in a soft plate because of undue distortion of the plate. Furthermore, the strength of the rivet is usually wasted because the joint is likely to be governed by the bearing value of the soft plate. Similarly, very soft rivets are not often used in hard plates. It is generally advantageous from a strength standpoint to use a rivet having about the same properties as the material in which it is driven, although from the driving standpoint it is often necessary to have the rivets somewhat softer. The following combinations of structure and rivets have been found to work together satisfactorily in many applications.

Structure	Rivets (Driven Tempers)
2S, any temper, 3S-O, 52S-O	2S-F
3S or 52S, quarter-hard or harder . .	53S-T61, 53S-T41, 61S-T43, 61S-T31
61S-T4, 61S-T6, 53S-T4, 53S-T6 . . .	53S-T61, 53S-T41, 53S-T6, 61S-T6, 61S-T43, 61S-T31, B77S-T41, Steel
14S-T6, 14S-T4, 24S-T4, 75S-T6 . . .	A17S-T3, 17S-T31, 17S-T41, 24S-T31, 61S-T43, B77S-T41, Steel

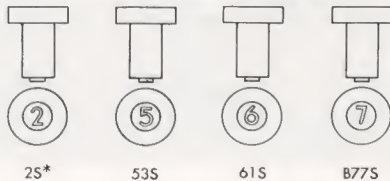
The following identification markings are used on aluminum alloy rivets except that rivets over $\frac{3}{4}$ inch in diameter and all sizes of high button head rivets are identified on the end of the shank with either the full alloy number or the Standard Shank Marking shown below:

RIVET IDENTIFICATION MARKINGS

Head Markings

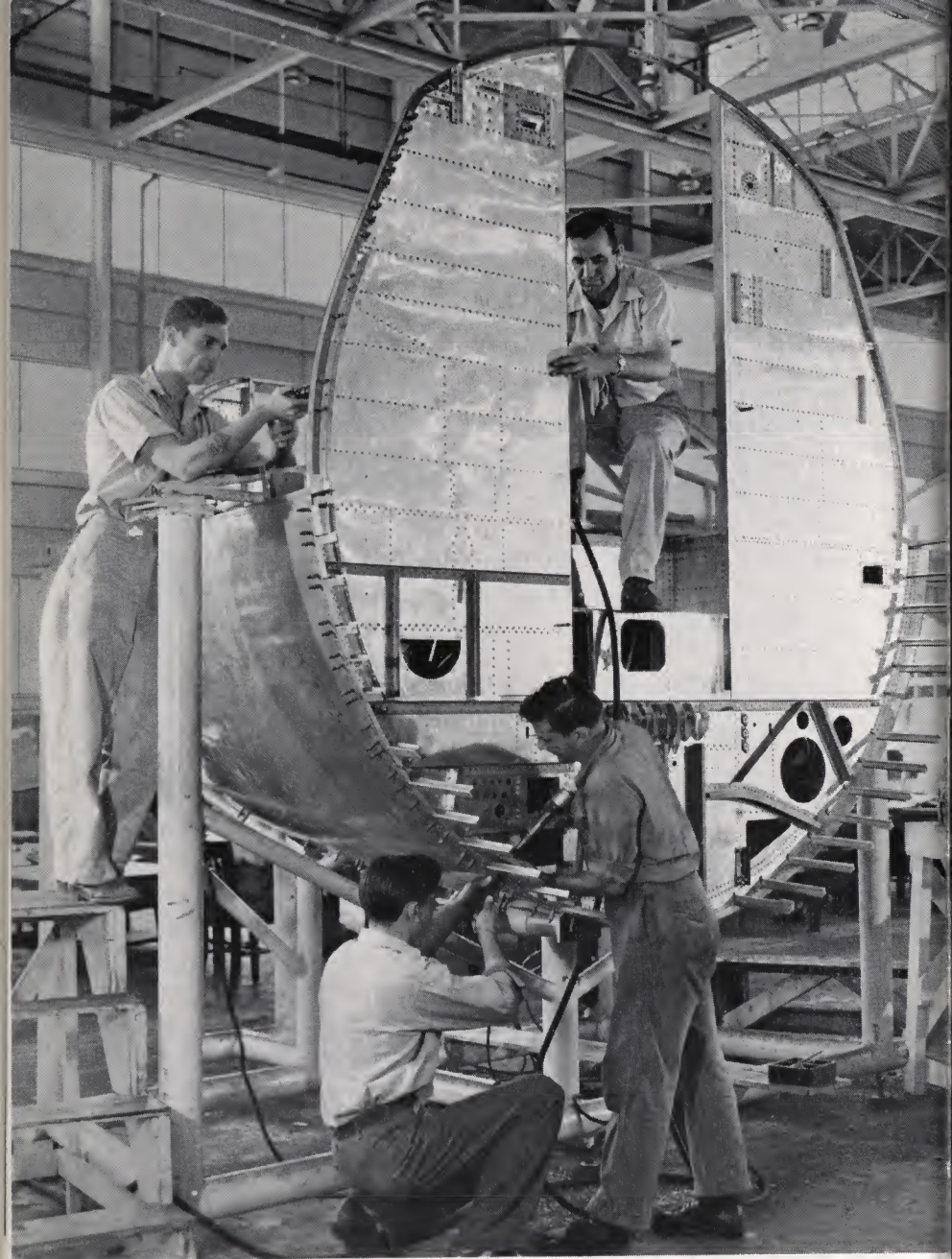


Shank Markings Raised Numbers on Shank Ends



*2S not marked unless so specified.

†Not a standard rivet alloy.



Drilling and riveting operation on aluminum alloy aircraft subassembly.

PROTECTION OF RIVETED JOINTS

THE degree of protection required against corrosion of riveted joints depends upon the severity of service conditions, the alloys used, and on the presence of dissimilar metals. The contact surfaces should be protected under most service conditions. After proper surface preparation (see "Finishes for Aluminum") the members should receive a coat of zinc chromate primer which is allowed to dry before assembly. An alternate procedure for thick sections is to apply a good grade of joint compound on the contact surfaces. If over-all painting is used, care should be taken to prime the rivet heads as well as the other parts of the structure before applying top coats. This is especially important where steel rivets are used.

Where aluminum is in contact with steel members, both priming and joint compound should be used on the contact surfaces. If conditions are unusually severe, such joints and those having steel rivets should be metallized, preferably after assembly, using zinc, 2S, or 72S. The assembled structure should receive a priming coat and top coats. Sand or steel grit blasting is necessary as a surface preparation for successful metallizing.

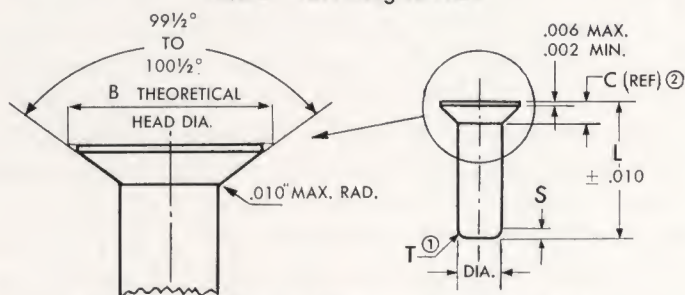
AIRCRAFT RIVETING

STANDARD rivet alloys used in aircraft are A17S-T4 and 24S-T4, which are identified as shown on page 45.

High-performance airplanes are usually flush-riveted on the outside. The thicker parts are frequently machine countersunk, and thin stock is usually dimpled. Another method is to machine countersink the member being attached to the skin, and then dimple the skin sheet to form a recess for the

rivet head in the outer surface of the sheet. AN-426 flush rivets are used for most outside surfaces. The universal head rivet, AN-470, is used where a flush surface is not required.

TABLE 14 — Dimensions and Tolerances of 100° Countersunk Head Rivets — Drawing AN426



Flush Type Rivet (100° Countersunk Head)

Dimensions are in inches

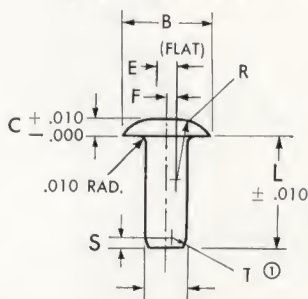
Diameter	B	C (Ref.) ^②	S	T Radius ^①
.062 $\begin{smallmatrix} +.003 \\ -.001 \end{smallmatrix}$	.114 $\begin{smallmatrix} +.004 \\ -.004 \end{smallmatrix}$	.022	.016	.019
.094 $\begin{smallmatrix} +.003 \\ -.001 \end{smallmatrix}$	.179 $\begin{smallmatrix} +.004 \\ -.004 \end{smallmatrix}$	.036	.023	.029
.125 $\begin{smallmatrix} +.003 \\ -.001 \end{smallmatrix}$	.225 $\begin{smallmatrix} +.004 \\ -.004 \end{smallmatrix}$	.042	.031	.039
.156 $\begin{smallmatrix} +.003 \\ -.001 \end{smallmatrix}$	.286 $\begin{smallmatrix} +.004 \\ -.004 \end{smallmatrix}$	.055	.039	.049
.187 $\begin{smallmatrix} +.003 \\ -.001 \end{smallmatrix}$	.353 $\begin{smallmatrix} +.004 \\ -.004 \end{smallmatrix}$	.070	.047	.059
.250 $\begin{smallmatrix} +.003 \\ -.001 \end{smallmatrix}$	.476 $\begin{smallmatrix} +.004 \\ -.004 \end{smallmatrix}$	.095	.062	.078
.312 $\begin{smallmatrix} +.003 \\ -.001 \end{smallmatrix}$	.564 $\begin{smallmatrix} +.004 \\ -.004 \end{smallmatrix}$	.106	.078	.098
.375 $\begin{smallmatrix} +.003 \\ -.001 \end{smallmatrix}$	.694 $\begin{smallmatrix} +.004 \\ -.004 \end{smallmatrix}$	.134	.094	.117

① Chamfered end optional.

② The height of head, C (Ref.) is given for reference only and is not used for inspection purposes. It is not subject to tolerance.

Tolerances on the two styles of aircraft rivets are given in Tables 14 and 15.

TABLE 15 — Dimensions and Tolerances of Universal Head Rivets —
Drawing AN470



Universal Head Rivet

Dimensions are in inches

Diameter	B	C	E	F	R	S	T ^① Radius
.062 $\begin{smallmatrix} +.003 \\ -.001 \end{smallmatrix}$	.125 $\pm .006$	.027	.031	.015	.054	.016	.019
.094 $\begin{smallmatrix} +.003 \\ -.001 \end{smallmatrix}$	.187 $\pm .009$	.040	.046	.023	.082	.023	.029
.125 $\begin{smallmatrix} +.003 \\ -.001 \end{smallmatrix}$	.250 $\pm .012$	.054	.062	.031	.108	.031	.039
.156 $\begin{smallmatrix} +.004 \\ -.001 \end{smallmatrix}$	.312 $\pm .016$	.067	.078	.039	.135	.039	.049
.187 $\begin{smallmatrix} +.004 \\ -.001 \end{smallmatrix}$	.375 $\pm .019$	.080	.093	.046	.164	.047	.059
.250 $\begin{smallmatrix} +.004 \\ -.001 \end{smallmatrix}$	.500 $\pm .025$	.107	.125	.062	.217	.062	.078
.312 $\begin{smallmatrix} +.004 \\ -.001 \end{smallmatrix}$	.625 $\pm .031$	.133	.156	.078	.272	.078	.098
.375 $\begin{smallmatrix} +.004 \\ -.001 \end{smallmatrix}$	.750 $\pm .037$	.161	.187	.093	.328	.094	.117

① Chamfered end optional.



Hand driving aluminum alloy rivets. Helper inside cabin is holding buck-up tool while the riveter operates the gun.

Note that so far only the preformed rivet heads have been discussed. In hand driving aircraft rivets, it is almost universal practice to apply the blow to a set (flat-ended for flush rivets) which is held firmly against the preformed head of the rivet, thus pushing it into the hole and tending to keep it there while the heading is accomplished. A bucking bar or dolly having a flat face is held lightly (so as not to push the rivet out against the thrust from the driving side) against the point or end of the rivet shank. The inertia of this tool provides the force that upsets the rivet, forming a flat or pancake type head. It should be noted that the structure in which the rivet is being driven must deflect with each blow to provide the movement necessary for upsetting the rivet. When the structure is too rigid to deflect easily, it is suggested that the above procedure be reversed, the blow being applied to the point instead of to the manufactured head.

Sub-assemblies are riveted wherever possible in fixed riveting equipment, which may be either of the single-stroke squeeze type or of the slow-operating hammer type. This method is considerably cheaper than the hand method, and usually produces a higher percentage of satisfactory rivets.

The rivet alloy most widely used in aircraft construction is A17S-T4. Where higher shear strength is required, 17S-T4 or 24S-T4 rivets are used. Several aircraft companies use A17S-T4 rivets exclusively for the smaller sizes, and 24S-T4 rivets for everything larger than a certain limiting size, such as $\frac{5}{32}$ -inch or $\frac{3}{16}$ -inch diameter. This simplifies the stock problem and reduces the possibility of accidentally using A17S-T4 rivets where the design requires a stronger material. After driving, they are designated as shown in Table 2, page 10.

Rivets of A17S-T4 are driven in the heat treated and completely aged condition, thus requiring no processing on the part of the user, other than the actual driving. After driving,

they are designated A17S-T3. Because of their somewhat higher properties, 17S-T4 rivets must be driven before they have aged appreciably if the head is to be formed to the usual diameter, which is $1\frac{1}{2}$ times the shank diameter. The head thickness is not so critical from the driving standpoint, but is usually required to be $\frac{1}{2}$ the shank diameter as a minimum. Smaller diameter heads can be formed satisfactorily even when aging has progressed considerably, and if the ratio of head to shank diameter is about $1\frac{1}{3}$ to 1, then 17S-T4 rivets, particularly in the smaller sizes, can usually be driven without difficulty. After driving, 17S rivets are designated 17S-T31 or 17S-T3 depending upon whether they are driven before or after the room temperature aging is completed.

The driving characteristics of 24S-T4 rivets are such that considerable care must be exercised if excessive head cracks are to be avoided. It is essential to prevent even the smallest amount of aging if heads $1\frac{1}{2}$ times the shank in diameter are to be formed successfully. It is recommended that 24S-T4 rivets be driven with heads only $1\frac{1}{3}$ times the shank diameter.

Rather than attempt to heat treat 17S-T4 and 24S-T4 rivets a few at a time at each place in the shop where they are being used, the usual practice is to heat treat them at a central unit and prevent aging after quenching by storing the rivets at a low temperature. The start of aging can be delayed for 8 or 10 hours by holding either alloy at 32°F. At 0°F no aging takes place for periods up to a week. It is desirable to cool the rivets as rapidly as possible in order to prevent aging from occurring before they reach the storage temperature, which is usually 0°F or somewhat lower. Immersing the rivets in an alcohol bath at 0°F will serve the double purpose of cooling the rivets rapidly and removing the quenching water so that they will not freeze into a solid mass.* Effective cooling

*Process covered by U. S. Patent 2,446,166 assigned to The Glenn L. Martin Co.

can also be obtained by maintaining the quenching water near the freezing point so that the rivets are immediately cooled to a temperature at which aging is arrested. The heat treated and chilled rivets can then be stored in a centrally located refrigerator. Small insulated boxes cooled by dry ice are useful for keeping small quantities of rivets in a workable condition at the individual work places.

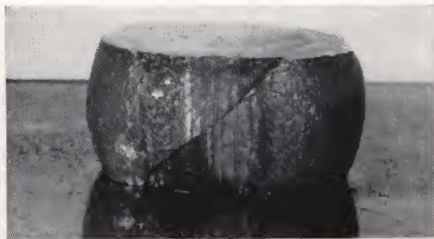
Rivets of alloys 17S-T4, A17S-T4 and 24S-T4 are supplied with an anodic coating, if such a coating is specified (required by Military Specification MIL-R-5674A). This coating improves the resistance of the rivets to corrosion and also provides a better surface for painting. For use in aircraft construction, rivets are usually supplied with the Alumilite 205 finish, which has a light yellow color.

While the driving operation tends to break the oxide film, joints made with 17S-T3 and 17S-T31 rivets which were given Alumilite 205 finish before driving, have been subjected to the standard salt spray test required for anodic-oxide coatings by the air services of both the U. S. Army and Navy without showing signs of corrosion.

Reheat treating rivets as many as fifteen times has been found to have no appreciable effect on the protection afforded by the Alumilite 205 treatment, provided that the rivets do not come in contact with the molten nitrate. The high temperature does, however, darken the color of the coating.

INSPECTION OF DRIVEN RIVETS

The standards to which driven rivets should conform are fre-



Example of severe head cracking on 24S-T31 rivet. Tests indicated that even this degree of cracking had no adverse effect on the static strength, fatigue strength, or resistance to corrosion.



Driven heads resulting from various driving pressures. The tensile strength of each one was within five per cent of the strongest one.

quently uncertain. In addition to dimensions (thickness, diameter) and perfection of shape, inspection is concerned with whether the driven head is co-axial with the shank (not "clinched") and whether there is excessive cracking of the heads. However, it has been determined that even badly cracked heads are satisfactory from the standpoint of static strength, fatigue strength, and resistance to corrosion. The series of rivet heads shown above was tested in tension to determine how well formed a head had to be in order to develop full strength. The tensile strengths of all of the rivets in the photograph were within five per cent of the strongest one. The foregoing is presented for the purpose of indicating that minor deviations from the theoretically desired shape of head are not cause for concern or replacement. Similarly the photograph on page 53 shows that cracks in rivet heads have no adverse effect on the strength of a rivet. The second rivet that is driven in any one hole is likely to be even more defective than the first, because the hole will be enlarged, and the rivet will be more likely to buckle and form an imperfect head.

DESIGN VALUES FOR AIRCRAFT RIVETS

Allowable shear and bearing design values for aluminum alloy aircraft rivets are selected by government agencies and given in "Strength of Metal Aircraft Elements—ANC-5a," which may be obtained from the Government Printing Office.

Table 16 presents some suggested values for grip lengths of rivets driven with normal flat heads. These grips are based on calculations, allowing sufficient metal to fill the hole and make a flat head having a diameter 1.4 times the rivet diameter and a height one-half of the rivet diameter. The hole sizes specified are taken from ANC-5a.

It is recommended that the information given in Table 16 be checked by actual driving tests before ordering rivets. This is advisable because rivet holes are often oversize and rivet grips are not always equal to the sum of the nominal thicknesses of metal through which the rivet is driven.

TABLE 16 — Maximum Grips for Various Lengths of Rivets

Rivet Diameter, In.	$\frac{1}{16}$	$\frac{3}{32}$	$\frac{1}{8}$	$\frac{5}{32}$	$\frac{3}{16}$	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$
Hole Diameter, In.	0.067	0.096	0.1285	0.159	0.191	0.257	0.323	0.386
Drill No.	51	41	30	21	11	F	P	W
Rivet Length, In.	Maximum* Rivet Grips for Given Lengths, Inches							
$\frac{3}{16}$	.110	.091	.061	.033	....	....	....	....
$\frac{1}{4}$	.164	.151	.120	.094	.064	....	....	....
$\frac{5}{16}$	.218	.210	.180	.153	.124	.062	....	....
$\frac{3}{8}$	.272	.270	.239	.214	.184	.122	.062	....
$\frac{7}{16}$	....	.330	.297	.275	.244	.182	.122	.067
$\frac{1}{2}$	....	.389	.356	.334	.305	.240	.181	.124
$\frac{9}{16}$	....	.449	.416	.395	.364	.300	.241	.184
$\frac{5}{8}$	....	....	.475	.456	.424	.360	.299	.244
$\frac{3}{4}$	....	....	.594	.577	.545	.477	.416	.360
$\frac{7}{8}$	....	....	....	.697	.665	.595	.534	.476
1	....	....	....	....	.785	.715	.650	.596
$1\frac{1}{4}$	....	....	....	....	....	.950	.884	.832
$1\frac{1}{2}$	....	....	....	....	....	1.187	1.120	1.069

*Assuming driven head is flat with diameter and depth of 1.4 and 0.5 respectively, times original rivet diameter.



TABULAR DATA

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19. Round head	62-3
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[illegible]

*A—Covers Standard Round, Button, Mushroom, Brazier and Modified Brazier Heads.

*B—Covers Standard Flat, 78° and 100° Countersunk Heads.

✓—Indicates sizes that chamfer tools are available for Radius Type Chamfer. Refer to Illustration No. 1, below.

□—Indicates sizes that chamfer tools are available for Bevel Type Chamfer. Refer to Illustration No. 2, below.

For sizes not identified by symbol ☒ or ☐ obtain tool charge from Alcoa.

†—Maximum lengths for $\sqrt{\text{Radius Type Chamfer.}}$

††—Maximum lengths for ☐ Bevel Type Chamfer.

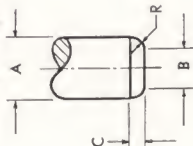


ILLUSTRATION NO. 1

Radius type chamfer

A = Shank diameter

B = Diameter of end flat

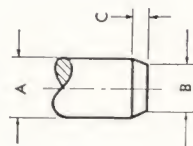
$$C = 0.25 \times A$$
$$\text{Radius} = 0.3125 \times A$$


ILLUSTRATION NO. 2

☐ Bevel type chamfer

A = Shank diameter

B = Approximate $0.86 \times A$

C = Approximate $0.25 \times A$

TABLE 18 — Sizes and Approximate Pieces per Pound,
Standard Button Head Rivets

Length, Inches	Nominal Diameter — Inches						
	$\frac{1}{16}$ 0.062	$\frac{3}{32}$ 0.094	$\frac{1}{8}$ 0.125	$\frac{5}{32}$ 0.156	$\frac{3}{16}$ 0.187	$\frac{7}{32}$ 0.219	$\frac{1}{4}$ 0.250
$\frac{1}{16}$	21,276	.....	.....	.....	.....	.....	.....
$\frac{3}{32}$	17,543	6,410	2,941	.....	.....	.....	.....
$\frac{1}{8}$	15,151	5,617	2,645	.....	.....	.....	.....
$\frac{3}{16}$	11,764	4,524	2,192	1,262	.....	.....	.....
$\frac{1}{4}$	9,615	3,802	1,876	1,096	699	471	331
$\frac{5}{16}$	8,130	3,267	1,636	970	621	423	300
$\frac{3}{8}$	7,042	2,865	1,453	869	561	386	274
$\frac{7}{16}$	6,211	2,551	1,305	787	512	353	253
$\frac{1}{2}$	5,555	2,298	1,186	719	471	326	234
$\frac{9}{16}$	5,025	2,092	1,085	657	434	303	218
$\frac{5}{8}$	4,587	1,923	1,002	609	404	283	205
$\frac{11}{16}$	4,219	1,776	925	568	378	265	192
$\frac{3}{4}$	3,906	1,650	869	531	354	250	182
$\frac{7}{8}$	3,401	1,447	763	471	316	223	163
1	3,012	1,287	684	423	284	202	148
$1\frac{1}{8}$	2,666	1,140	621	383	257	183	136
$1\frac{1}{4}$	2,417	1,037	565	351	236	169	126
$1\frac{3}{8}$	.....	951	521	324	218	156	117
$1\frac{1}{2}$	.....	879	481	300	203	146	109
$1\frac{3}{4}$	.....	762	418	262	178	128	96.2
2	.....	673	370	233	158	114	85.5
$2\frac{1}{4}$	.....	.....	333	209	142	103	77.5
$2\frac{1}{2}$	.....	.....	302	190	130	93.5	70.9
$2\frac{3}{4}$	.....	.....	276	174	119	86.2	64.9
3	.....	.....	254	161	110	79.4	60.2
$3\frac{1}{4}$	.....	.....	.....	149	102	74.1	55.9
$3\frac{1}{2}$	.....	.....	.....	139	95.2	69.0	52.4
$3\frac{3}{4}$	.....	.....	.....	130	89.3	64.9	49.3
4	.....	.....	.....	123	84.0	61.0	46.3
$4\frac{1}{4}$	.....	.....	.....	.....	79.4	57.8	43.9
$4\frac{1}{2}$	.....	.....	.....	.....	75.2	55.0	41.7
$4\frac{3}{4}$	.....	.....	.....	.....	71.4	52.1	39.4
5	.....	.....	.....	.....	68.0	49.8	37.7
$5\frac{1}{4}$	.....	.....	.....	.....	.....	47.4	36.0
$5\frac{1}{2}$	.....	.....	.....	.....	.....	.....	34.5

(Concluded on opposite page)

TABLE 18 (Concluded) — Sizes and Approximate Pieces per Pound, Standard Button Head Rivets

Length, Inches	Nominal Diameter — Inches							
	$\frac{9}{32}$ 0.281	$\frac{5}{16}$ 0.312	$\frac{3}{8}$ 0.375	$\frac{7}{16}$ 0.437	$\frac{1}{2}$ 0.500	$\frac{9}{16}$ 0.562	$\frac{5}{8}$ 0.625	$\frac{3}{4}$ 0.750
$\frac{1}{16}$	.....	.....	.....	.....	.....	.....	.....	.....
$\frac{3}{32}$	.....	.....	.....	.....	.....	.....	.....	.....
$\frac{1}{8}$	.....	.....	.....	.....	.....	.....	.....	.....
$\frac{3}{16}$	.....	.....	.....	.....	.....	.....	.....	.....
$\frac{1}{4}$	244	186	114	.....	.....	.....	.....	.....
$\frac{5}{16}$	223	170	105	.....	.....	.....	.....	.....
$\frac{3}{8}$	205	157	98	.....	.....	.....	.....	.....
$\frac{7}{16}$	190	146	92	.....	.....	.....	.....	.....
$\frac{1}{2}$	176	136	86	58	41	30	23	.....
$\frac{9}{16}$	165	128	81	55	39	29	22	.....
$\frac{5}{8}$	155	121	77	52	37	27	21	.....
$1\frac{1}{16}$	146	114	73	50	35	26	20	.....
$\frac{3}{4}$	138	108	69	48	34	25	19	12
$\frac{7}{8}$	125	98	63	44	31	23	18	11
1	113	89	58	40	29	22	17	11
$1\frac{1}{8}$	105	82.0	54.1	37.6	27.5	20.7	16.0	10.2
$1\frac{1}{4}$	97.1	76.3	50.3	35.1	25.7	19.5	15.1	9.7
$1\frac{3}{8}$	90.1	70.9	47.0	32.9	24.2	18.3	14.3	9.2
$1\frac{1}{2}$	84.0	66.2	44.0	31.0	22.8	17.3	13.5	8.7
$1\frac{3}{4}$	74.1	58.8	39.2	27.8	20.5	15.6	12.2	7.9
2	66.7	52.9	35.3	25.1	18.6	14.3	11.2	7.3
$2\frac{1}{4}$	60.2	47.9	32.3	22.9	17.0	13.1	10.3	6.8
$2\frac{1}{2}$	55.0	43.9	29.6	21.1	15.7	12.1	9.5	6.3
$2\frac{3}{4}$	50.8	40.5	27.3	19.5	14.6	11.2	8.9	5.9
3	47.0	37.5	25.4	18.2	13.6	10.5	8.3	5.5
$3\frac{1}{4}$	43.7	35.0	23.7	17.0	12.7	9.8	7.8	5.2
$3\frac{1}{2}$	41.0	32.8	22.2	16.0	12.0	9.3	7.4	4.9
$3\frac{3}{4}$	38.5	30.8	21.0	15.1	11.3	8.8	6.9	4.7
4	36.2	29.1	19.8	14.3	10.7	8.3	6.6	4.4
$4\frac{1}{4}$	34.4	27.6	18.8	13.5	10.2	7.9	6.3	4.2
$4\frac{1}{2}$	32.6	26.2	17.8	12.9	9.7	7.5	6.0	4.0
$4\frac{3}{4}$	31.0	24.9	17.0	.....	.....	.....	.....	.....
5	29.6	23.8	16.2	.....	.....	.....	.....	.....
$5\frac{1}{4}$	28.3	22.7	15.5	.....	.....	.....	.....	.....
$5\frac{1}{2}$	27.0	21.7	14.9	.....	.....	.....	.....	.....

TABLE 19 — Sizes and Approximate Pieces per Pound,
Standard Round Head Rivets

Length, Inches	Nominal Diameter — Inches						
	$\frac{1}{16}$ 0.062	$\frac{3}{32}$ 0.094	$\frac{1}{8}$ 0.125	$\frac{5}{32}$ 0.156	$\frac{3}{16}$ 0.187	$\frac{7}{32}$ 0.219	$\frac{1}{4}$ 0.250
$\frac{1}{16}$	18,882	6,223	2,833	.....	.....	.....	.....
$\frac{3}{32}$	15,969	5,480	2,553	1,395	834	.....	.....
$\frac{1}{8}$	13,833	4,897	2,324	1,286	778	511	354
$\frac{3}{16}$	10,913	4,037	1,970	1,113	685	456	319
$\frac{1}{4}$	9,012	3,434	1,709	981	612	412	291
$\frac{5}{16}$	7,675	2,988	1,510	877	553	375	267
$\frac{3}{8}$	6,683	2,644	1,352	793	505	344	246
$\frac{7}{16}$	5,918	2,371	1,224	724	464	318	229
$\frac{1}{2}$	5,310	2,149	1,118	666	429	296	214
$\frac{9}{16}$	4,816	1,966	1,029	616	399	277	200
$\frac{5}{8}$	4,406	1,811	953	573	373	260	189
$\frac{11}{16}$	4,060	1,679	888	536	351	245	178
$\frac{3}{4}$	3,764	1,564	830	504	330	231	169
$\frac{7}{8}$	3,286	1,377	736	449	296	208	153
1	2,916	1,230	661	405	269	190	140
$1\frac{1}{8}$	2,620	1,111	600	369	246	174	129
$1\frac{1}{4}$	2,379	1,013	549	339	226	161	119
$1\frac{3}{8}$	.....	931	505	313	210	149	111
$1\frac{1}{2}$	.....	861	469	291	196	140	104
$1\frac{3}{4}$	.....	749	410	255	172	123	92
2	.....	663	364	227	154	110	83
$2\frac{1}{4}$	.....	.....	327	205	139	100	75
$2\frac{1}{2}$	.....	.....	297	186	127	91	69
$2\frac{3}{4}$	.....	.....	272	171	116	84	63
3	.....	.....	251	158	108	78	59
$3\frac{1}{4}$	.....	.....	.....	147	100	72	55
$3\frac{1}{2}$	.....	.....	.....	137	94	68	51
$3\frac{3}{4}$	.....	.....	.....	128	88	64	48
4	.....	.....	.....	121	83	60	45
$4\frac{1}{4}$	.....	.....	.....	.....	78	57	43
$4\frac{1}{2}$	.....	.....	.....	.....	74	54	41
$4\frac{3}{4}$	.....	.....	.....	.....	71	51	39
5	.....	.....	.....	.....	67	49	37
$5\frac{1}{4}$	.....	.....	.....	.....	.....	47	35
$5\frac{1}{2}$	.....	.....	.....	.....	.....	.....	34

(Concluded on opposite page)

TABLE 19 (Concluded) — Sizes and Approximate Pieces per Pound, Standard Round Head Rivets

Length, Inches	Nominal Diameter — Inches							
	$\frac{9}{32}$ 0.281	$\frac{5}{16}$ 0.312	$\frac{3}{8}$ 0.375	$\frac{7}{16}$ 0.437	$\frac{1}{2}$ 0.500	$\frac{9}{16}$ 0.562	$\frac{5}{8}$ 0.625	$\frac{3}{4}$ 0.750
$\frac{1}{16}$	.....	.....	.....	.....	.....	.....	.....	.....
$\frac{3}{32}$	.....	.....	.....	.....	.....	.....	.....	.....
$\frac{1}{8}$	.....	.....	.....	.....	.....	.....	.....	.....
$\frac{3}{16}$	232	174	105	.....	.....	.....	.....	.....
$\frac{1}{4}$	213	160	98	64	44	.....	.....	.....
$\frac{5}{16}$	197	149	92	60	42	30	23	.....
$\frac{3}{8}$	182	139	86	57	40	29	22	13
$\frac{7}{16}$	170	130	81	54	38	28	21	13
$\frac{1}{2}$	160	122	77	51	36	27	20	12
$\frac{5}{8}$	150	116	73	49	35	26	19	12
$\frac{3}{4}$	142	109	69	47	33	25	19	11
$1\frac{1}{16}$	134	104	66	45	32	24	18	11
$\frac{7}{8}$	127	99	63	43	31	23	17	11
1	116	90	58	40	29	21	16	10
$1\frac{1}{8}$	106	83	54	37	27	20	15	10
$1\frac{1}{4}$	98	77	50	35	25	19	14	9.1
$1\frac{3}{8}$	91	72	47	32	24	18	14	8.7
$1\frac{1}{2}$	85	67	44	31	22	17	13	8.3
$1\frac{3}{4}$	80	63	41	29	21	16	12	7.9
2	71	56	37	26	19	15	11	7.3
$2\frac{1}{4}$	64	51	34	24	17	13	10	6.7
$2\frac{1}{2}$	58	46	31	22	16	12	10	6.3
$2\frac{3}{4}$	53	42	28	20	15	11	8.9	5.9
3	49	39	26	19	14	11	8.4	5.5
$3\frac{1}{4}$	46	36	24	17	13	10	7.9	5.2
$3\frac{1}{2}$	43	34	23	16	12	9.4	7.4	4.9
$3\frac{3}{4}$	40	32	22	15	12	8.9	7.0	4.6
4	38	30	20	15	11	8.4	6.6	4.4
$4\frac{1}{4}$	35	28	19	14	10	8.0	6.3	4.2
$4\frac{1}{2}$	34	27	18	13	9.8	7.6	6.0	4.0
$4\frac{3}{4}$	32	26	17	12	9.4	7.3	5.8	3.8
5	30	24	17	.....	.....	.....	.....	.....
$5\frac{1}{4}$	29	23	16	.....	.....	.....	.....	.....
$5\frac{1}{2}$	28	22	15	.....	.....	.....	.....	.....
$5\frac{3}{4}$	27	21	15	.....	.....	.....	.....	.....

TABLE 20 — Sizes and Approximate Pieces per Pound,
Standard Mushroom Head Rivets

Length, Inches	Nominal Diameter — Inches						
	$\frac{1}{16}$ 0.062	$\frac{3}{32}$ 0.094	$\frac{1}{8}$ 0.125	$\frac{5}{32}$ 0.156	$\frac{3}{16}$ 0.187	$\frac{7}{32}$ 0.219	$\frac{1}{4}$ 0.250
$\frac{1}{16}$	19,685	6,536	2,985	.....	.....	.....	.....
$\frac{3}{32}$	16,528	5,714	2,674	1,466	877	.....	.....
$\frac{1}{8}$	14,265	5,076	2,421	1,346	813	538	373
$\frac{3}{16}$	11,173	4,167	2,041	1,157	714	476	334
$\frac{1}{4}$	9,174	3,521	1,764	1,016	636	429	303
$\frac{5}{16}$	7,812	3,058	1,550	905	571	389	277
$\frac{3}{8}$	6,802	2,695	1,385	813	521	356	255
$\frac{7}{16}$	5,988	2,415	1,252	741	476	329	236
$\frac{1}{2}$	5,376	2,183	1,140	680	441	305	221
$\frac{9}{16}$	4,878	1,996	1,048	629	410	284	206
$\frac{5}{8}$	4,444	1,835	971	585	382	266	194
$1\frac{1}{16}$	4,098	1,701	901	546	358	251	183
$\frac{3}{4}$	3,802	1,582	840	513	338	236	173
$\frac{7}{8}$	3,311	1,391	746	457	302	213	156
1	2,933	1,241	667	412	273	193	143
$1\frac{1}{8}$	2,635	1,120	606	373	249	177	131
$1\frac{1}{4}$	2,391	1,020	556	342	229	163	121
$1\frac{3}{8}$	.....	937	510	316	212	152	113
$1\frac{1}{2}$	.....	867	474	294	198	141	105
$1\frac{3}{4}$	.....	753	413	258	174	125	93.5
2	.....	666	366	229	155	111	83.3
$2\frac{1}{4}$	.....	.....	329	206	140	101	75.8
$2\frac{1}{2}$	.....	.....	298	187	128	92.6	69.4
$2\frac{3}{4}$	.....	.....	273	172	117	84.7	64.1
3	.....	.....	252	159	108	78.1	59.2
$3\frac{1}{4}$	.....	.....	.....	147	101	73.0	54.9
$3\frac{1}{2}$	.....	.....	.....	138	94.3	68.0	51.5
$3\frac{3}{4}$	.....	.....	.....	129	88.5	64.1	48.5
4	.....	.....	.....	121	83.3	60.6	45.7
$4\frac{1}{4}$	.....	.....	.....	.....	78.7	57.1	43.3
$4\frac{1}{2}$	.....	.....	.....	.....	74.6	54.3	41.2
$4\frac{3}{4}$	.....	.....	.....	.....	70.9	51.5	39.1
5	.....	.....	.....	.....	67.6	49.3	37.3
$5\frac{1}{4}$	.....	.....	.....	.....	.....	46.9	35.6
$5\frac{1}{2}$	.....	.....	.....	.....	.....	.....	34.1

(Concluded on opposite page)

TABLE 20 (Concluded) — Sizes and Approximate Pieces per Pound, Standard Mushroom Head Rivets

Length, Inches	Nominal Diameter — Inches							
	$\frac{9}{32}$ 0.281	$\frac{5}{16}$ 0.312	$\frac{3}{8}$ 0.375	$\frac{7}{16}$ 0.437	$\frac{1}{2}$ 0.500	$\frac{9}{16}$ 0.562	$\frac{5}{8}$ 0.625	$\frac{3}{4}$ 0.750
$\frac{1}{16}$	.....	.....	.....	.....	.....	.....	.....	.....
$\frac{3}{32}$	.....	.....	.....	.....	.....	.....	.....	.....
$\frac{1}{8}$	.....	.....	.....	.....	.....	.....	.....	.....
$\frac{3}{16}$	244	182	111	.....	.....	.....	.....	.....
$\frac{1}{4}$	222	168	103	67.1	46.5	.....	.....	.....
$\frac{5}{16}$	204	155	96.2	63.3	44.1	31.9	23.9	.....
$\frac{3}{8}$	189	144	90.1	59.5	41.8	30.4	22.8	13.8
$\frac{7}{16}$	176	135	84.7	56.5	39.7	29.1	21.8	13.3
$\frac{1}{2}$	165	127	80.0	53.5	37.9	27.8	21.0	12.8
$\frac{9}{16}$	155	119	75.8	51.0	36.2	26.7	20.2	12.4
$\frac{5}{8}$	146	113	71.9	48.5	34.6	25.6	19.4	12.0
$\frac{11}{16}$	138	107	68.5	46.5	33.2	24.6	18.7	11.6
$\frac{3}{4}$	131	102	65.4	44.4	31.9	23.7	18.1	11.2
$\frac{7}{8}$	119	92.6	59.9	41.0	29.6	22.0	16.9	10.6
1	109	84.7	55.2	38.0	27.5	20.6	15.8	10.0
$1\frac{1}{8}$	100	78.7	51.3	35.6	25.8	19.4	14.9	9.4
$1\frac{1}{4}$	92.6	73.0	47.8	33.3	24.2	18.2	14.1	9.0
$1\frac{3}{8}$	87.0	68.0	44.8	31.3	22.9	17.3	13.4	8.5
$1\frac{1}{2}$	81.3	64.1	42.2	29.6	21.6	16.4	12.7	8.2
$1\frac{3}{4}$	71.9	56.8	37.7	26.6	19.5	14.9	11.6	7.5
2	64.5	51.3	34.2	24.2	17.8	13.6	10.6	6.9
$2\frac{1}{4}$	58.8	46.7	31.2	22.1	16.4	12.5	9.8	6.4
$2\frac{1}{2}$	53.8	42.7	28.7	20.4	15.2	11.6	9.1	6.0
$2\frac{3}{4}$	49.5	39.5	26.6	18.9	14.1	10.8	8.5	5.6
3	46.1	36.8	24.8	17.7	13.2	10.1	8.0	5.3
$3\frac{1}{4}$	42.9	34.2	23.1	16.6	12.4	9.5	7.5	5.0
$3\frac{1}{2}$	40.2	32.2	21.8	15.6	11.7	9.0	7.1	4.7
$3\frac{3}{4}$	37.9	30.3	20.5	14.7	11.0	8.5	6.7	4.5
4	35.7	28.6	19.4	13.9	10.4	8.1	6.4	4.3
$4\frac{1}{4}$	33.8	27.1	18.4	13.2	9.9	7.7	6.1	4.1
$4\frac{1}{2}$	32.1	25.8	17.5	12.6	9.5	7.3	5.8	3.9
$4\frac{3}{4}$	30.6	24.5	16.7	.....	.....	.....	.....	.....
5	29.2	23.4	15.9	.....	.....	.....	.....	.....
$5\frac{1}{4}$	27.9	22.4	15.3	.....	.....	.....	.....	.....
$5\frac{1}{2}$	27.4	21.5	14.7	.....	.....	.....	.....	.....

TABLE 21 — Sizes and Approximate Pieces per Pound,
Standard Brazier Head Rivets

Length, Inches	NOMINAL DIAMETER — INCHES						
	$\frac{1}{16}$ 0.062	$\frac{3}{32}$ 0.094	$\frac{1}{8}$ 0.125	$\frac{5}{32}$ 0.156	$\frac{3}{16}$ 0.187	$\frac{7}{32}$ 0.219	$\frac{1}{4}$ 0.250
$\frac{1}{16}$	19,833	6,587	3,012	.....	.....	.....	.....
$\frac{3}{32}$	16,644	5,761	2,698	1,479	887	.....	.....
$\frac{1}{8}$	14,337	5,120	2,443	1,357	823	543	377
$\frac{3}{16}$	11,225	4,187	2,055	1,166	720	481	337
$\frac{1}{4}$	9,223	3,542	1,773	1,022	640	432	305
$\frac{5}{16}$	7,827	3,069	1,559	910	576	392	279
$\frac{3}{8}$	6,798	2,708	1,391	820	523	358	257
$\frac{7}{16}$	6,009	2,422	1,256	748	480	330	238
$\frac{1}{2}$	5,383	2,191	1,145	684	443	306	222
$\frac{5}{8}$	4,876	2,000	1,052	632	411	286	207
$\frac{3}{4}$	4,456	1,840	973	587	384	268	195
$1\frac{1}{16}$	4,102	1,704	905	548	360	252	184
$\frac{7}{8}$	3,800	1,586	845	514	338	237	174
1	3,314	1,394	748	457	303	213	157
$1\frac{1}{8}$	2,937	1,243	670	412	274	194	143
$1\frac{1}{4}$	2,638	1,122	607	375	250	178	131
$1\frac{1}{2}$	2,393	1,022	555	343	230	164	122
$1\frac{3}{8}$	.....	939	511	317	213	152	113
$1\frac{1}{2}$	.....	868	474	295	198	142	106
$1\frac{3}{4}$	.....	754	413	258	174	125	93
2	.....	666	366	229	155	112	84
$2\frac{1}{4}$	.....	.....	329	206	140	101	76
$2\frac{1}{2}$	.....	.....	299	188	128	92	69
$2\frac{3}{4}$	.....	.....	273	172	117	85	64
3	.....	.....	252	159	108	78	59
$3\frac{1}{4}$	.....	.....	.....	148	100	73	55
$3\frac{1}{2}$	.....	.....	.....	138	94	68	52
$3\frac{3}{4}$	.....	.....	.....	129	88	64	49
4	.....	.....	.....	122	83	60	46
$4\frac{1}{4}$	.....	.....	.....	.....	79	57	43
$4\frac{1}{2}$	.....	.....	.....	.....	75	54	41
$4\frac{3}{4}$	.....	.....	.....	.....	71	52	39
5	.....	.....	.....	.....	68	49	37
$5\frac{1}{4}$	.....	.....	.....	.....	.....	47	36
$5\frac{1}{2}$	.....	.....	.....	.....	.....	.....	34

(Concluded on opposite page)

TABLE 21 (Concluded) — Sizes and Approximate Pieces per Pound, Standard Brazier Head Rivets

Length, Inches	NOMINAL DIAMETER — INCHES							
	$\frac{9}{32}$ 0.281	$\frac{5}{16}$ 0.312	$\frac{3}{8}$ 0.375	$\frac{7}{16}$ 0.437	$\frac{1}{2}$ 0.500	$\frac{9}{16}$ 0.562	$\frac{5}{8}$ 0.625	$\frac{3}{4}$ 0.750
$\frac{1}{16}$	.....	.....	.....	.....	.....	.....	.....	.....
$\frac{3}{32}$	.....	.....	.....	.....	.....	.....	.....	.....
$\frac{1}{8}$	.....	.....	.....	.....	.....	.....	.....	.....
$\frac{3}{16}$	246	184	112	.....	.....	.....	.....	.....
$\frac{1}{4}$	224	169	103	68	47	.....	.....	.....
$\frac{5}{16}$	206	156	97	64	45	32	24	.....
$\frac{3}{8}$	191	145	90	60	42	31	23	14
$\frac{7}{16}$	177	136	85	57	40	29	22	13
$\frac{1}{2}$	166	127	80	54	38	28	21	13
$\frac{9}{16}$	155	120	76	51	36	27	20	13
$\frac{5}{8}$	147	113	72	49	35	26	20	12
$\frac{11}{16}$	139	108	69	47	33	25	19	12
$\frac{3}{4}$	132	102	66	45	32	24	18	11
$\frac{7}{8}$	119	93	60	41	30	22	17	11
1	109	85	56	38	28	21	16	10
$1\frac{1}{8}$	100	79	52	36	26	19	15	9.5
$1\frac{1}{4}$	93	73	48	33	24	18	14	9.0
$1\frac{3}{8}$	87	68	45	31	23	17	13	8.6
$1\frac{1}{2}$	81	64	42	30	22	16	13	8.2
$1\frac{3}{4}$	72	57	38	27	20	15	12	7.5
2	65	51	34	24	18	14	11	6.9
$2\frac{1}{4}$	59	47	31	22	16	13	9.9	6.4
$2\frac{1}{2}$	54	43	29	20	15	12	9.2	6.0
$2\frac{3}{4}$	50	40	27	19	14	11	8.6	5.6
3	46	37	25	18	13	10	8.0	5.3
$3\frac{1}{4}$	43	34	23	17	12	9.6	7.6	5.0
$3\frac{1}{2}$	40	32	22	16	12	9.0	7.1	4.7
$3\frac{3}{4}$	38	30	21	15	11	8.5	6.8	4.5
4	36	29	19	14	10	8.1	6.4	4.3
$4\frac{1}{4}$	34	27	18	13	10	7.7	6.1	4.1
$4\frac{1}{2}$	32	26	18	13	9.5	7.4	5.9	3.9
$4\frac{3}{4}$	31	25	17	.....	.....	.....	.....	.....
5	29	23	16	.....	.....	.....	.....	.....
$5\frac{1}{4}$	28	22	15	.....	.....	.....	.....	.....
$5\frac{1}{2}$	27	22	15	.....	.....	.....	.....	.....

TABLE 22 — Sizes and Approximate Pieces per Pound,
Standard High Button Head Rivets

Length, Inches	NOMINAL DIAMETER — INCHES				
	1/2—0.500	5/8—0.625	3/4—0.750	7/8—0.875	1—1.000
1/2	43	.....	.....	.....	.....
9/16	41	.....	.....	.....	.....
5/8	39	22	.....	.....	.....
11/16	37	21	.....	.....	.....
3/4	35	20	13	.....	.....
13/16	34	20	13	.....	.....
7/8	33	19	12	8.3	.....
15/16	31	18	12	8.1	.....
1	30	18	11	7.8	5.6
1 1/8	28	17	11	7.4	5.3
1 1/4	26	16	10	7.0	5.0
1 3/8	25	15	9.5	6.6	4.8
1 1/2	23	14	9.1	6.3	4.6
1 5/8	22	13	8.6	6.0	4.4
1 3/4	21	13	8.3	5.8	4.2
1 7/8	20	12	7.9	5.5	4.0
2	19	11	7.6	5.3	3.9
2 1/4	17	11	7.0	4.9	3.6
2 1/2	16	9.7	6.5	4.6	3.4
2 3/4	15	9.0	6.0	4.3	3.2
3	14	8.5	5.6	4.0	3.0
3 1/4	13	7.9	5.3	3.8	2.8
3 1/2	12	7.5	5.0	3.6	2.7
3 3/4	11	7.0	4.8	3.4	2.5
4	11	6.7	4.5	3.2	2.4
4 1/4	10	6.4	4.3	3.1	2.3
4 1/2	9.8	6.1	4.1	2.9	2.2

TABLE 23 — Sizes and Approximate Pieces per Pound,
Standard Modified Brazier Head Rivets

Length, Inches	NOMINAL DIAMETER — INCHES							
	$\frac{1}{16}$ 0.062	$\frac{3}{32}$ 0.094	$\frac{1}{8}$ 0.125	$\frac{5}{32}$ 0.156	$\frac{3}{16}$ 0.187	$\frac{1}{4}$ 0.250	$\frac{5}{16}$ 0.312	$\frac{3}{8}$ 0.375
$\frac{3}{32}$	23,256	.....	.....	.....	.....	.....	.....	.....
$\frac{1}{8}$	19,231	.....	.....	.....	.....	.....	.....	.....
$\frac{3}{16}$	14,085	6,188	2,932	.....	.....	.....	.....	.....
$\frac{1}{4}$	11,111	4,876	2,392	1,362	840	.....	.....	.....
$\frac{5}{16}$	9,174	4,023	2,016	1,168	735	.....	.....	.....
$\frac{3}{8}$	7,813	3,423	1,745	1,025	649	369	.....	.....
$\frac{7}{16}$	6,803	2,980	1,536	909	584	331	.....	.....
$\frac{1}{2}$	6,024	2,638	1,373	819	531	300	169	.....
$\frac{9}{16}$	5,405	2,366	1,240	746	485	274	156	.....
$\frac{5}{8}$	4,902	2,145	1,132	684	448	253	145	91
$1\frac{1}{16}$	4,484	1,962	1,040	632	414	234	136	86
$\frac{3}{4}$	4,132	1,808	961	588	387	218	128	81
$\frac{7}{8}$	3,571	1,562	840	515	341	192	113	72
1	3,135	1,375	740	458	305	172	103	66
$1\frac{1}{8}$	2,801	1,228	666	413	276	155	93	60
$1\frac{1}{4}$	2,532	1,110	602	375	251	141	85	55
$1\frac{3}{8}$	.....	1,012	549	344	232	130	79	51
$1\frac{1}{2}$	.....	930	507	317	214	120	73	48
$1\frac{3}{4}$	.....	801	440	275	186	105	64	42
2	.....	703	387	243	165	92	57	38
$2\frac{1}{2}$	.....	.....	312	197	134	75	46	31
3	.....	.....	262	165	113	63	39	26
$3\frac{1}{2}$	.....	.....	.....	142	98	55	34	23
4	.....	.....	.....	125	86	48	30	20

TABLE 24 — Sizes and Approximate Pieces per Pound,
Standard Flat Head Rivets

Length, Inches	NOMINAL DIAMETER — INCHES						
	$\frac{1}{16}$ 0.062	$\frac{3}{32}$ 0.094	$\frac{1}{8}$ 0.125	$\frac{5}{32}$ 0.156	$\frac{3}{16}$ 0.187	$\frac{7}{32}$ 0.219	$\frac{1}{4}$ 0.250
$\frac{1}{16}$	20,190	6,723	3,079	.....	.....	.....	.....
$\frac{3}{32}$	16,895	5,865	2,751	1,510	907	.....	.....
$\frac{1}{8}$	14,522	5,202	2,487	1,384	840	554	385
$\frac{3}{16}$	11,338	4,242	2,086	1,185	733	490	344
$\frac{1}{4}$	9,299	3,581	1,796	1,037	650	439	311
$\frac{5}{16}$	7,882	3,098	1,577	921	584	398	284
$\frac{3}{8}$	6,839	2,730	1,405	829	530	363	261
$\frac{7}{16}$	6,041	2,440	1,268	754	485	335	241
$\frac{1}{2}$	5,409	2,206	1,154	691	448	310	224
$\frac{5}{8}$	4,897	2,013	1,060	637	415	289	210
$\frac{3}{4}$	4,473	1,851	980	592	387	270	197
$1\frac{1}{16}$	4,117	1,713	911	552	363	254	186
$\frac{3}{4}$	3,814	1,594	851	518	341	240	176
$\frac{7}{8}$	3,323	1,400	752	460	305	215	158
1	2,945	1,248	673	414	276	195	144
$1\frac{1}{8}$	2,644	1,126	610	376	252	179	132
$1\frac{1}{4}$	2,398	1,025	557	345	231	165	122
$1\frac{3}{8}$	.....	941	513	319	214	153	114
$1\frac{1}{2}$	.....	870	475	296	199	143	106
$1\frac{3}{4}$	.....	755	414	259	175	126	94
2	.....	668	367	230	156	112	84
$2\frac{1}{4}$	.....	.....	330	207	141	101	76
$2\frac{1}{2}$	.....	.....	293	188	128	93	70
$2\frac{3}{4}$	.....	.....	274	172	118	85	64
3	.....	.....	253	159	109	79	59
$3\frac{1}{4}$	.....	.....	.....	148	101	73	55
$3\frac{1}{2}$	.....	.....	.....	138	94	69	52
$3\frac{3}{4}$	.....	.....	.....	129	89	64	49
4	.....	.....	.....	122	84	61	46
$4\frac{1}{4}$	.....	.....	.....	.....	79	57	43
$4\frac{1}{2}$	.....	.....	.....	.....	75	54	41
$4\frac{3}{4}$	.....	.....	.....	.....	71	52	39
5	.....	.....	.....	.....	68	49	38
$5\frac{1}{4}$	.....	.....	.....	.....	.....	47	36
$5\frac{1}{2}$	.....	.....	.....	.....	.....	.....	34

(Concluded on opposite page)

TABLE 24 (Concluded) — Sizes and Approximate Pieces per Pound, Standard Flat Head Rivets

Length, Inches	NOMINAL DIAMETER — INCHES							
	$\frac{9}{32}$ 0.281	$\frac{5}{16}$ 0.312	$\frac{3}{8}$ 0.375	$\frac{7}{16}$ 0.437	$\frac{1}{2}$ 0.500	$\frac{9}{16}$ 0.562	$\frac{5}{8}$ 0.625	$\frac{3}{4}$ 0.750
$\frac{1}{16}$	.....	.....	.....	.....	.....	.....	.....	.....
$\frac{3}{32}$	.....	.....	.....	.....	.....	.....	.....	.....
$\frac{1}{8}$	.....	.....	.....	.....	.....	.....	.....	.....
$\frac{3}{16}$	251	188	114	.....	.....	.....	.....	.....
$\frac{1}{4}$	228	172	106	69	48	.....	.....	.....
$\frac{5}{16}$	210	159	98	65	45	33	25	.....
$\frac{3}{8}$	194	148	92	61	43	31	24	14
$\frac{7}{16}$	180	138	87	58	41	30	23	14
$\frac{1}{2}$	168	129	82	55	39	29	22	13
$\frac{5}{8}$	158	122	77	52	37	27	21	13
$\frac{3}{4}$	149	115	73	50	35	26	20	12
$1\frac{1}{16}$	140	109	70	48	34	25	19	12
$\frac{7}{8}$	133	103	67	45	33	24	19	12
1	121	94	61	42	30	23	17	11
$1\frac{1}{8}$	110	86	56	39	28	21	16	10
$1\frac{1}{4}$	101	80	52	36	26	20	15	9.7
$1\frac{1}{2}$	94	74	49	34	25	19	14	9.2
$1\frac{3}{8}$	88	69	46	32	23	18	14	8.7
$1\frac{1}{2}$	82	65	43	30	22	17	13	8.3
$1\frac{3}{4}$	73	58	38	27	20	15	12	7.6
2	65	52	35	24	18	14	11	7.0
$2\frac{1}{4}$	59	47	32	22	17	13	9.9	6.5
$2\frac{1}{2}$	54	43	29	21	15	12	9.2	6.1
$2\frac{3}{4}$	50	40	27	19	14	11	8.6	5.7
3	46	37	25	18	13	10	8.1	5.3
$3\frac{1}{4}$	43	35	23	17	13	9.6	7.6	5.0
$3\frac{1}{2}$	40	32	22	16	12	9.1	7.2	4.8
$3\frac{3}{4}$	38	30	21	15	11	8.6	6.8	4.5
4	36	29	20	14	11	8.1	6.5	4.3
$4\frac{1}{4}$	34	27	19	13	10	7.8	6.2	4.1
$4\frac{1}{2}$	32	26	18	13	9.5	7.4	5.9	3.9
$4\frac{3}{4}$	31	25	17	.....	.....	.....	.....	.....
5	29	24	16	.....	.....	.....	.....	.....
$5\frac{1}{4}$	28	23	15	.....	.....	.....	.....	.....
$5\frac{1}{2}$	27	22	15	.....	.....	.....	.....	.....

TABLE 25 — Sizes and Approximate Pieces per Pound,
Standard 78° Flat Countersunk Head Rivets

Length, Inches	NOMINAL DIAMETER — INCHES						
	$\frac{1}{16}$ 0.062	$\frac{3}{32}$ 0.094	$\frac{1}{8}$ 0.125	$\frac{5}{32}$ 0.156	$\frac{3}{16}$ 0.187	$\frac{7}{32}$ 0.219	$\frac{1}{4}$ 0.250
$\frac{1}{16}$	34,483	12,937	6,369	.....	.....	.....	.....
$\frac{3}{32}$	25,840	10,095	5,102	2,976	1,883	.....	.....
$\frac{1}{8}$	20,661	8,264	4,274	2,525	1,618	1,110	797
$\frac{3}{16}$	14,771	6,098	3,205	1,934	1,261	877	641
$\frac{1}{4}$	11,494	4,808	2,571	1,567	1,034	730	535
$\frac{5}{16}$	9,434	3,984	2,146	1,318	877	621	459
$\frac{3}{8}$	7,937	3,390	1,838	1,136	763	541	402
$\frac{7}{16}$	6,897	2,956	1,610	1,000	671	478	357
$\frac{1}{2}$	6,098	2,618	1,433	893	602	431	322
$\frac{9}{16}$	5,444	2,353	1,289	806	543	391	292
$\frac{5}{8}$	4,926	2,132	1,172	735	498	357	268
$1\frac{1}{16}$	4,504	1,953	1,075	676	459	330	248
$\frac{3}{4}$	4,132	1,799	990	625	424	306	230
$\frac{7}{8}$	3,571	1,555	862	541	369	267	201
1	3,135	1,370	758	478	328	237	179
$1\frac{1}{8}$	2,797	1,224	680	429	294	213	161
$1\frac{1}{4}$	2,524	1,106	613	389	267	194	147
$1\frac{3}{8}$	.....	1,009	562	356	244	177	134
$1\frac{1}{2}$	.....	927	515	328	225	164	124
$1\frac{3}{4}$	.....	799	444	282	195	142	108
2	.....	701	392	249	171	125	95.2
$2\frac{1}{4}$	.....	.....	349	222	153	112	85.5
$2\frac{1}{2}$	.....	.....	315	200	138	101	76.9
$2\frac{3}{4}$	.....	.....	287	183	126	92.2	70.4
3	.....	.....	264	168	116	84.7	64.5
$3\frac{1}{4}$	.....	.....	.....	155	107	78.7	59.9
$3\frac{1}{2}$	.....	.....	.....	145	99.8	73.0	55.6
$3\frac{3}{4}$	.....	.....	.....	135	93.5	68.5	52.1
4	.....	.....	.....	127	87.7	64.1	49.0
$4\frac{1}{4}$	.....	.....	.....	.....	82.6	60.6	46.1
$4\frac{1}{2}$	.....	.....	.....	.....	78.1	57.1	43.7
$4\frac{3}{4}$	.....	.....	.....	.....	74.1	54.3	41.5
5	.....	.....	.....	.....	70.4	51.5	39.4
$5\frac{1}{4}$	.....	.....	.....	.....	.....	49.3	37.6
$5\frac{1}{2}$	.....	.....	.....	.....	.....	.....	35.8

(Concluded on opposite page)

TABLE 25 (Concluded) — Sizes and Approximate Pieces per Pound, Standard 78° Flat Countersunk Head Rivets

Length, Inches	NOMINAL DIAMETER — INCHES							
	$\frac{9}{32}$ 0.281	$\frac{5}{16}$ 0.312	$\frac{3}{8}$ 0.375	$\frac{7}{16}$ 0.437	$\frac{1}{2}$ 0.500	$\frac{9}{16}$ 0.562	$\frac{5}{8}$ 0.625	$\frac{3}{4}$ 0.750
$\frac{1}{16}$	.....	.....	.....	.....	.....	.....	.....	.....
$\frac{3}{32}$	.....	.....	.....	.....	.....	.....	.....	.....
$\frac{1}{8}$	592	.....	.....	.....	.....	.....	.....	.....
$\frac{3}{16}$	481	372	236	.....	.....	.....	.....	.....
$\frac{1}{4}$	405	314	203	139	99.6	.....	.....	.....
$\frac{5}{16}$	350	273	178	123	88.5	66.2	51.0	32.2
$\frac{3}{8}$	308	242	158	110	79.9	60.2	46.5	29.5
$\frac{7}{16}$	275	216	142	99.5	72.5	55.0	42.6	27.2
$\frac{1}{2}$	248	196	130	90.9	66.7	50.1	39.4	25.4
$\frac{9}{16}$	226	179	119	84.0	61.7	46.9	36.6	23.7
$\frac{5}{8}$	207	164	110	77.5	57.1	43.7	34.1	22.2
$\frac{11}{16}$	192	152	102	72.5	53.5	40.8	32.1	20.9
$\frac{3}{4}$	179	142	95.2	67.6	50.3	38.5	30.2	19.8
$\frac{7}{8}$	156	125	84.0	60.2	44.6	34.2	27.0	17.8
1	139	111	75.2	53.8	40.2	31.0	24.4	16.2
$1\frac{1}{8}$	126	101	68.0	48.8	36.5	28.2	22.4	14.9
$1\frac{1}{4}$	115	91.7	62.1	44.6	33.6	25.9	20.6	13.7
$1\frac{3}{8}$	105	84.0	57.3	41.2	31.0	24.0	19.0	12.8
$1\frac{1}{2}$	97.1	78.1	53.2	38.2	28.7	22.3	17.8	11.9
$1\frac{3}{4}$	84.0	67.6	46.3	33.4	29.4	20.0	15.6	10.5
2	74.6	60.0	41.0	29.7	22.4	17.5	13.9	9.4
$2\frac{1}{4}$	66.7	53.8	36.8	26.7	20.2	15.7	12.6	8.5
$2\frac{1}{2}$	60.2	48.5	33.3	24.2	18.3	14.3	11.5	7.8
$2\frac{3}{4}$	55.2	44.4	30.5	22.2	16.8	13.1	10.5	7.1
3	50.8	41.0	28.1	20.4	15.5	12.1	9.7	6.6
$3\frac{1}{4}$	47.0	37.9	26.1	19.0	14.4	11.3	9.1	6.2
$3\frac{1}{2}$	43.9	35.3	24.3	17.7	13.4	10.5	8.5	5.8
$3\frac{3}{4}$	41.0	33.1	22.8	16.6	12.6	9.9	7.9	5.4
4	38.5	31.1	21.4	15.6	11.9	9.3	7.5	5.1
$4\frac{1}{4}$	36.4	29.3	20.2	14.7	11.2	8.8	7.1	4.9
$4\frac{1}{2}$	34.4	27.8	19.1	14.0	10.6	8.3	6.7	4.6
$4\frac{3}{4}$	32.6	26.3	18.1	.....	.....	.....	.....	.....
5	31.1	25.1	17.3	.....	.....	.....	.....	.....
$5\frac{1}{4}$	29.6	23.9	16.5	.....	.....	.....	.....	.....
$5\frac{1}{2}$	28.2	22.8	15.8	.....	.....	.....	.....	.....

TABLE 26 — Sizes and Approximate Pieces per Pound,
Standard 78° Oval Countersunk Head Rivets

Length, Inches	NOMINAL DIAMETER — INCHES						
	$\frac{1}{16}$ 0.062	$\frac{3}{32}$ 0.094	$\frac{1}{8}$ 0.125	$\frac{5}{32}$ 0.156	$\frac{3}{16}$ 0.187	$\frac{7}{32}$ 0.219	$\frac{1}{4}$ 0.250
$\frac{1}{16}$	27,027	9,524	4,505	.....	.....	.....	.....
$\frac{3}{32}$	21,459	7,874	3,831	2,165	1,328	.....	.....
$\frac{1}{8}$	17,762	6,757	3,344	1,912	1,190	800	562
$\frac{3}{16}$	13,218	5,208	2,660	1,553	990	671	481
$\frac{1}{4}$	10,526	4,237	2,203	1,309	840	581	418
$\frac{5}{16}$	8,772	3,584	1,887	1,130	736	510	370
$\frac{3}{8}$	7,463	3,100	1,642	990	649	455	332
$\frac{7}{16}$	6,536	2,732	1,458	885	585	410	301
$\frac{1}{2}$	5,814	2,445	1,311	801	532	375	275
$\frac{5}{8}$	5,208	2,208	1,189	730	485	344	254
$\frac{3}{4}$	4,739	2,012	1,089	671	448	317	235
$1\frac{1}{16}$	4,348	1,852	1,005	621	415	296	219
$\frac{7}{8}$	4,005	1,712	934	578	388	276	205
1	3,472	1,493	813	508	341	244	182
$1\frac{1}{8}$	3,058	1,319	725	450	305	219	164
$1\frac{1}{4}$	2,736	1,183	649	407	276	198	149
$1\frac{3}{8}$	2,474	1,073	592	370	252	181	136
$1\frac{1}{2}$	.....	981	541	340	231	167	126
$1\frac{3}{4}$	.....	904	500	314	214	155	117
2	.....	781	433	273	187	135	102
$2\frac{1}{4}$	.....	688	382	241	165	120	90.1
$2\frac{1}{2}$	.....	.....	341	216	148	107	81.3
$2\frac{3}{4}$	.....	.....	309	195	134	98.0	74.1
3	.....	.....	.....	179	123	89.3	67.6
$3\frac{1}{4}$	.....	.....	.....	164	113	82.3	62.5
$3\frac{1}{2}$	.....	.....	.....	152	105	76.3	58.1
$3\frac{3}{4}$	.....	.....	.....	142	98.0	71.4	54.1
4	.....	.....	.....	133	91.7	66.7	50.8
$4\frac{1}{4}$	.....	.....	.....	125	86.2	62.9	47.8
$4\frac{1}{2}$	.....	.....	.....	.....	81.3	59.2	45.0
$4\frac{3}{4}$	.....	.....	.....	.....	76.9	56.2	42.7
5	.....	.....	.....	.....	73.0	53.2	40.7
$5\frac{1}{4}$	.....	.....	.....	.....	69.4	50.8	38.6
$5\frac{1}{2}$	.....	.....	.....	.....	.....	48.3	36.9
	.....	.....	.....	.....	.....	.....	35.3

(Concluded on opposite page)

TABLE 26 (Concluded) — Sizes and Approximate Pieces per Pound, Standard 78° Oval Countersunk Head Rivets

Length, Inches	NOMINAL DIAMETER — INCHES							
	$\frac{9}{32}$ 0.281	$\frac{5}{16}$ 0.312	$\frac{3}{8}$ 0.375	$\frac{7}{16}$ 0.437	$\frac{1}{2}$ 0.500	$\frac{9}{16}$ 0.562	$\frac{5}{8}$ 0.625	$\frac{3}{4}$ 0.750
$\frac{1}{16}$	.....	.....	.....	.....	.....	.....	.....	.....
$\frac{3}{32}$	.....	.....	.....	.....	.....	.....	.....	.....
$\frac{1}{8}$	.....	.....	.....	.....	.....	.....	.....	.....
$\frac{3}{16}$	356	270	167	.....	.....	.....	.....	.....
$\frac{1}{4}$	312	239	149	100	70.4	.....	.....	.....
$\frac{5}{16}$	278	214	136	90.9	64.9	47.6	36.1	.....
$\frac{3}{8}$	251	194	124	84.0	59.2	44.4	33.7	20.9
$\frac{7}{16}$	228	177	114	77.8	55.9	41.5	31.6	19.7
$\frac{1}{2}$	210	163	106	72.5	52.2	38.9	29.9	18.7
$\frac{9}{16}$	193	151	98.0	67.8	49.0	36.8	28.2	17.8
$\frac{5}{8}$	180	141	91.7	63.7	46.3	34.7	26.7	16.9
$1\frac{1}{16}$	168	132	86.2	60.2	43.7	32.9	25.4	16.2
$\frac{3}{4}$	158	124	81.3	56.8	41.5	31.3	24.2	15.5
$\frac{7}{8}$	140	111	73.2	51.3	37.6	28.5	22.2	14.2
1	126	100	66.7	46.7	34.4	26.2	20.4	13.2
$1\frac{1}{8}$	115	90.9	61.0	42.9	31.7	24.2	18.9	12.3
$1\frac{1}{4}$	106	84.0	56.2	39.7	29.4	22.5	17.6	11.5
$1\frac{3}{8}$	97.1	77.5	52.1	36.9	27.4	21.0	16.5	10.8
$1\frac{1}{2}$	90.9	71.9	48.5	34.5	25.7	19.7	15.5	10.2
$1\frac{3}{4}$	79.4	63.3	42.7	30.5	22.8	17.5	13.9	9.2
2	70.4	56.5	38.2	27.4	20.5	15.8	12.5	8.3
$2\frac{1}{4}$	63.7	50.8	34.5	24.8	18.6	14.4	11.4	7.6
$2\frac{1}{2}$	57.8	46.3	31.5	22.7	17.0	13.2	10.5	7.0
$2\frac{3}{4}$	52.9	42.6	29.0	20.9	15.7	12.2	9.7	6.5
3	49.0	39.2	26.8	19.3	14.5	11.3	9.0	6.1
$3\frac{1}{4}$	45.5	36.5	24.9	18.0	13.6	10.6	8.4	5.7
$3\frac{1}{2}$	42.4	34.1	23.3	16.9	12.7	9.9	7.9	5.3
$3\frac{3}{4}$	39.8	31.9	21.9	15.8	12.0	9.3	7.5	5.1
4	37.5	30.1	20.6	15.0	11.3	8.8	7.0	4.8
$4\frac{1}{4}$	35.5	28.5	19.5	14.2	10.7	8.4	6.7	4.5
$4\frac{1}{2}$	33.6	27.0	18.5	13.4	10.2	7.9	6.4	4.3
$4\frac{3}{4}$	31.8	25.6	17.6	.....	.....	.....	.....	.....
5	30.4	24.4	16.8	.....	.....	.....	.....	.....
$5\frac{1}{4}$	29.0	23.3	16.0	.....	.....	.....	.....	.....
$5\frac{1}{2}$	27.7	22.3	15.3	.....	.....	.....	.....	.....

TABLE 27 — Sizes and Approximate Pieces per Pound,
Standard 60° Oval Countersunk Head Rivets

Length, Inches	NOMINAL DIAMETER — INCHES				
	1/2—0.500	5/8—0.625	3/4—0.750	7/8—0.875	1—1.000
1/2	64	.....	.....	.....	.....
9/16	59	.....	.....	.....	.....
5/8	55	33	.....	.....	.....
11/16	52	31	.....	.....	.....
3/4	49	29	19	.....	.....
13/16	46	28	18	.....	.....
7/8	43	26	17	12	.....
15/16	41	25	16	11	.....
1	39	24	16	11	8.0
1 1/8	36	22	14	10	7.4
1 1/4	33	20	13	9.4	6.9
1 3/8	30	19	12	8.8	6.5
1 1/2	28	17	12	8.2	6.1
1 5/8	26	16	11	7.8	5.7
1 3/4	25	15	10	7.3	5.4
1 7/8	23	14	10	6.9	5.2
2	22	14	9.3	6.6	4.9
2 1/4	20	12	8.3	6.0	4.5
2 1/2	18	11	7.6	5.5	4.1
2 3/4	17	10	7.0	5.1	3.7
3	15	10	6.5	4.7	3.5
3 1/4	14	8.9	6.1	4.4	3.3
3 1/2	13	8.4	5.7	4.1	3.1
3 3/4	13	7.9	5.4	3.9	2.9
4	12	7.4	5.1	3.7	2.8
4 1/4	11	7.0	4.8	3.5	2.6
4 1/2	11	6.7	4.5	3.3	2.5

TABLE 29 — Sizes and Approximate Pieces per Pound,
Standard 100° Flat Countersunk Head Rivets

Length, Inches	NOMINAL DIAMETER — INCHES							
	1/16 0.062	3/32 0.094	1/8 0.125	5/32 0.156	3/16 0.187	1/4 0.250	5/16 0.312	3/8 0.375
1/8	22,727	.....	.....	.....	.....	.....	.....	.....
3/16	15,873	6,211	.....	.....	.....	.....	.....	.....
1/4	12,195	4,901	2,754	1,677	1,094	.....	.....	.....
5/16	9,900	4,032	2,267	1,394	917	.....	.....	.....
3/8	8,333	3,424	1,930	1,194	793	413	.....	.....
7/16	7,194	2,976	1,677	1,043	699	366	239	.....
1/2	6,329	2,638	1,485	925	621	328	215	140
9/16	5,649	2,364	1,331	833	561	298	194	127
5/8	5,102	2,141	1,207	757	512	273	178	117
11/16	4,651	1,956	1,103	694	469	251	164	108
3/4	4,273	1,805	1,017	641	434	234	152	101
7/8	3,676	1,557	877	555	378	204	132	88
1	3,225	1,371	775	490	334	181	117	79
1 1/8	2,873	1,223	689	438	299	163	105	71
1 1/4	2,577	1,106	625	395	271	148	95	65
1 3/8	.....	1,008	568	361	248	135	88	59
1 1/2	.....	925	523	332	228	125	81	55
1 3/4	.....	798	444	286	197	108	70	47
2	.....	701	392	251	173	95	61	42
2 1/2	.....	.....	315	200	139	77	50	34
3	.....	.....	264	168	117	64	42	29
3 1/2	.....	.....	.....	145	100	55	35	24

TABLE 30 — Sizes and Approximate Pieces per Pound,
Standard Tinnert's Rivets

Size No.*	Length, Inches	Approximate Pieces Per Lb.	Size No.*	Length, Inches	Approximate Pieces Per Lb.
8 Oz.	0.160	5203	4 Lb.	0.340	676
12 Oz.	0.190	3305	6 Lb.	0.390	442
1 Lb.	0.200	2799	8 Lb.	0.440	323
1 1/2 Lb.	0.230	1750	10 Lb.	0.470	269
2 Lb.	0.270	1248	12 Lb.	0.500	212
2 1/2 Lb.	0.280	1147	14 Lb.	0.520	165
3 Lb.	0.310	891	16 Lb.	0.530	142

*Size numbers refer to the "trade name" or weight of 1000 STEEL rivets.

TABLE 31 — Commercial Tolerances*

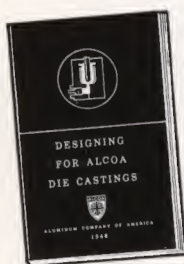
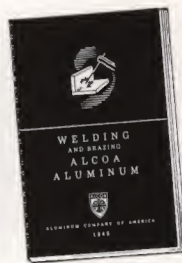
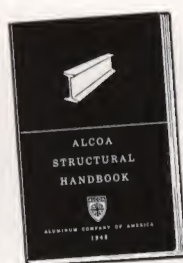
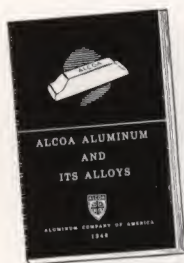
	Nominal Diameter, Inch	Minus Inch	Plus Inch
Shank diameter	0.052 to 0.094.....	0.002	0.004
	0.095 to 0.156.....	0.002	0.005
	0.157 to 0.219.....	0.003	0.006
	0.220 to 0.375.....	0.003	0.008
	0.376 to 0.625.....	0.005	0.010
	0.626 to 0.750.....	0.006	0.012
	0.751 to 1.000.....	0.007	0.015
Diameter of Head	All rivets with shank diameters to and including $\frac{3}{4}$ inch $\pm$ 8 per cent of nominal head diameter, but in no case less than $\pm$.010 inch, and in no case greater than $\pm$ $\frac{1}{32}$ inch. All rivets with shank diameters over $\frac{3}{4}$ inch $\pm$.047 inch.		
Height of Head	Plus or minus 8 per cent of nominal head height, but in no case less than $\pm$.010 inch or more than $\pm$.025 inch.		
Length of Shank	All diameters to $\frac{3}{4}$ inch inclusive $\pm$ $\frac{1}{64}$ inch. All diameters over $\frac{3}{4}$ inch $\pm$ $\frac{1}{32}$ inch.		
Packing	Bulk or one-pound packages, see Yellow Price Data for packing extra per pound.		
Shipping tolerance	Plus or minus 10 per cent of weight ordered.		
*	"Commercial Tolerances" meet the requirements of Military Specification, MIL-R-1150A.		

TABLE 32 — Military Specifications

Alloy and Temper	Grade	Specified Minimum Shear Strength*, Pounds per Square Inch	Specification Number
2S-F	A	No Shear Test Required	MIL-R-5674
A17S-T4	AD		MIL-R-5674
17S-T4	D		MIL-R-5674
24S-T4	DD		MIL-R-5674
53S-T61	E		MIL-R-1150
61S-T6	F		MIL-R-1150

*Based on Tests of Undriven Rivets.

Other Literature in the Alcoa Library



DESIGNING FOR ALCOA DIE CASTINGS

Handbook of design considerations as they affect economy, strength and production of die castings. Profusely illustrated with 170 comprehensive figures and photographs. 190 pages.

ALCOA ALUMINUM AND ITS ALLOYS

Fundamental information concerning the alloys produced by Aluminum Company of America. 179 pages, 25 illustrations, and 107 data-packed tables.

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Explains the fabrication of aluminum by blanking and piercing, drawing, spinning, shape forming, embossing, coining and stamping. 77 pages. 14 tables. 25 figures and photographs.

ALCOA STRUCTURAL HANDBOOK

Section elements of various structural shapes produced in Alcoa Aluminum, together with strength data on members fabricated in the various alloys. Discussions, examples, figures and tables. 214 pages.

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Detailed information on torch welding, arc welding, resistance welding and the various methods of brazing. Includes a discussion of the recently developed tungsten-arc welding. 136 pages. 55 illustrations with 6 color plates of welding flame adjustments. 18 tables.

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of Helpful Information on Aluminum



ALCOA ALUMINUM IMPACT EXTRUSIONS

This helpful booklet for the designer explains the impact extrusion process and describes the factors affecting designs. Pictures of a number of typical applications. 48 pages. 5 tables. 37 illustrations.

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A 40-page pamphlet listing "How-to-do-it" films on such subjects as Welding, Brazing, Riveting, Forming and Machining; other films and educational booklets; charts and school literature.

ALCOA BUILDING, PITTSBURGH 19, PA.

PRODUCTS SOLD BY ALCOA

NOTE: This list of products contains a minimum number of cross-referenced items necessary for the readers' convenience. Many products—cast, forged, draw pressed, extruded, impact extruded, screw machine and job shop—are produced to customers' specifications. Your nearest Alcoa sales office can be helpful in recommending the most efficient application of these products to your needs.

ACSR (aluminum cable
steel reinforced)

Alclad aluminum

Pipe

Plate

Sheet

Tube

Wire

Aluminas (see Chemicals)

Angles

Bar

Hexagonal

Rectangular

Special shapes for screw machine stock

Barrels

Beams

Beer barrels

Billets or blooms for wrought
aluminum products

Bolts

Brazing flux and wire

Bus (see Electrical
conductors)

Cable (see Electrical
conductors)

Carboys

Casting alloy ingot

Castings

Die

Permanent mold

Plaster mold

Sand

Semipermanent mold

Channels

Chemicals

Aluminas

Activated

Calcined

Hydrated

Low soda

Tabular

ALCOA PRODUCTS (*Continued*)**Chemicals** (*Concluded*)

Aluminum fluoride
Cryolite
Fluoboric acid
Gallium
Sodium acid fluoride
Sodium fluoride

Circles, sheet and plate

Closures, bottle

Sealing machines

Coiled sheet

Coiled tube

Cold-headed products

Collapsible tubes for pack-
aging tooth paste, drugs,
calking compounds,
greases, etc.

Conduit, rigid

Copings

Corrugated sheet

Cryolite insecticide

Die castings

Draw press products

Drums, shipping

Electrical conductors

Cable, all-aluminum or
ACSR (aluminum
cable steel reinforced)

Cable fittings and accessories

Buses

Channels

Flat

Tubular

Bus fittings and accessories

Fuse wire

Wire

Electrical metallic tubing

Extruded shapes

Fasteners

Bolts

Nails

Nuts

Rivets

Screws

Screw machine products

Washers

Finishes

Alumilite

Alrok

Electroplating

Other finishes are available

Fluoboric acid

Fluorides (see Chemicals)

Foil

Condenser

Insulating

Household

Milkbottle hoods

Packaging

Forgings, hammer and press

Fuse wire

Gallium

Grained ingot

Gravel stops

H-beams

Hammer forgings

Handrail pipe and fittings

I-beams

Impact extrusion products

Ingot

Casting alloy

For wrought products

Metallurgical granulated

Insecticide, cryolite

Irrigation pipe

Continued on next page

ALCOA PRODUCTS (Continued)

- Kettles
- Lighting sheet
- Lithograph sheet
- Milkbottle hoods, foil
- Moldings (see Extruded shapes)
- Nails
- Nuts
- Paint pigment, aluminum
- Patterned sheet
- Permanent mold castings
- Piano plates
- Pig
- Pigments
 - Powder and paste for paint and printing ink
- Pipe (see also Tube)
 - Construction
 - Handrail, and fittings
 - Irrigation
 - Standard, and fittings
- Pistons
- Plate (see Sheet)
 - Alclad
 - Circles
 - Odd-shaped blanks with sheared or sawed edges
 - Rectangular
 - Tapered
 - Tread
- Plaster mold castings
- Powder, aluminum (see also Pigments)
 - Dusting
 - Rubber compounding
- Press forgings
- Process equipment (made to specification)
- Rectangular tube
- Rectangular wire, rod and bar
- Reflector sheet
- Rivets and rivet wire
- Rod
 - Redraw
 - Round
- Roofing sheet
- Sand castings
- Screening wire
- Screws
 - Machine
 - Sheet metal
 - Special types
 - Wood
- Screw machine products (made to specification)
- Screw machine stock (see also Rod, Bar)
- Seals (bottle closures) and sealing machines
- Semipermanent mold castings
- Sheet (see also Plate)
 - Alclad
 - Circles
 - Coiled
 - Flat
 - Odd-shaped blanks with sheared or sawed edges
- Specialty sheet
 - Alumilite
 - Brazing
 - Corrugated

ALCOA PRODUCTS (Concluded)

Sheet (<i>Concluded</i>)	Tube (see also Pipe)
Specialty sheet	Alclad
Lithograph	Coiled
Patterned	Electrical metallic
Recording circles	Heat exchanger
Reflector	Round
Roofing	Square
Siding	Special shapes
Tapered	Tubes, collapsible
Shipping containers	Welding materials
Beer barrels	Flux
Carboys	Wire
Drums	Washers
Siding sheet	Wheels, truck, trailer and bus
Sodium acid fluoride	Disc
Sodium fluoride	Spoke
Solder and flux	Window sills
Spandrels	Wire
Square tube	Alclad
Structural assemblies (made	Flattened
to specification)	Hexagonal
Structural shapes (rolled and	Rectangular
extruded)	Round
Tanks, welded	Rivet
Tees	Special shapes
Thin-wall containers	Square
Thread lubricant and compound	Welding
Thresholds	Wire, electrical (see Electrical
Tool and jig plates	conductors)
Tooth paste tubes	Zees
Tread plate	

COMMERCIAL FORMS OF MAGNESIUM PRODUCTS sold by Alcoa include Castings, Forgings, Sheet and Plate, Extrusions, Tube and Pipe, Rod and Bar, and Structural Shapes. Also available are Pipe Line and Water Tank Anodes.

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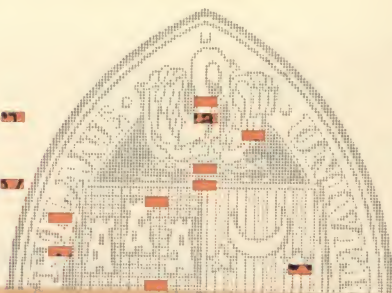
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